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Lockdown Effects on the Coronavirus (COVID-19) Pandemic – The Evidence from Norway

by

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Abstract

The first coronavirus disease 2019 (COVID-19) outbreak in China and has become a public health emergency of international concern. Several countries have issued comprehensive social distancing policies responses to the pandemic. This study was performed in an attempt to understand the impact of a lockdown on COVID-19 cases through a case study in Scandinavia. A validated database was used to originate data related to measurements and a difference-in-differences design was conducted to assess the effectiveness of Norway's lockdown. Our results show that a lockdown reduced the number of infected cases by 43 percent and it takes at least three weeks for the effect of the policy to appear. Further, Sweden, the state that opted against a lockdown seems to be more affected by the pandemic in terms of economic development. In general, this study focused on the short-term public health benefits of stringent anti-contagion policies. Future research is suggested to estimate the long-run effect of measures due to changes in perception of COVID-19 or other factors.

Keywords: Pandemic, COVID-19 cases, lockdown, difference-in-differences, Scandinavia

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1 Introduction

In December 2019, the first case of Corona-virus disease was identified in Wuhan of the People's Republic of China, and has rapidly spread to all world's prevalent economies by multiple ways of transmission in around 2 months with severe harmful respiratory symptoms, leading to an ongoing pandemic till today. During the first-wave pandemic, nearly 3,6 million accumulated covid-19 disease cases confirmed were announced globally, including almost 250 thousand deaths till 30th of April, 2020. Since the early outbreak in the Lombardy region of northern Italy, EU countries have gradually accounted for more than 40% of the total number of deaths. From 13 of March, 2020, the Director-General of WHO stated that Europe had become the epicentre of the pandemic with more reported cases than the rest of the world combined. To prevent the rapid transmission of COVID 19, a number of countries implemented national lockdown which includes border control, domestic non-essential travel restrictions, home isolation, and closure of all non-essential business (restaurant, hair salon, etc). Italy was the first in Europe to enforce comprehensive social distancing policies, when 11 municipalities across two provinces in Northern Italy were placed under a stringent lockdown. Other states follow Italy's lead to try to stem cases, however, Sweden is the only in Europe to avoid some kind of measures.

Faced with such an emergency public health event, the lockdown policy was designed with the intention to protect lives and safety as a priority. However, the implementation of such strict mandatory measures to protect the lives of citizens leads to a trade-off, entailing severe economic recession and social costs. According to EU statistics, the economy of the entire European Union region started to shrink by an overall 7.4 percent since early 2020 measured by real gross domestic product growth rate. Besides this, the EU tourism industry, service, and manufacturing sectors, in which 26 million people were registered to be unemployed in the labor market, estimated to be losing approximately two billion euros in revenue per month. On the one hand, there are increasing calls for opening the economy at a faster pace because of soaring economic costs of lockdown, rising unemployment rates, and shrinking GDP estimates (Borio, 2020). On the other hand, opening the economy too soon could result in a much higher human toll. It is essential to quantify both the costs and the benefits of social distancing policies to inform policymakers as the pandemic progresses. Hence, it is crucial to know how effective the measures are in containing the spread of COVID-19. A bunch of studies is therefore performed in an attempt to investigate the effect of anti-contagion policies on the pandemic through an event study on either European or non-European states.

Born et al. (2020) and Kepp and Bjørnskov (2021) are the only to examine the effect of a lockdown on Nordic countries, where one show strong evidence of a lockdown on COVID-19 confirmed cases reduction while the other one show no evidence on reducing the number of infections. As the existing empirical studies about the effect of mitigation policies on Nordic regions have no identical results, this paper fills the gap in the recent literature and adds to the recent body of evidence on the extent of reduction in COVID-19 spread. The two Scandinavian countries, Norway and Sweden, have relatively low average population densities and geographical advantages far from the epicenter which are the latest regions in Europe to be affected by the first wave of epidemics. Moreover, they form an ideal laboratory for a case study. First, the two countries are similar in terms of health care institutions, culture, climate, and institutional framework. Second, it is plausible that transmission of the virus started at approximately the same time in both countries due to geographical proximity, and economic connections. In fact, till the 26th of February 2020, there was only one record of the confirmed case of infection in Norway and two records in Sweden. However, in just one week, the situation has gradually deteriorated because of the continuously increasing number of epidemics in the whole world. Norway and Sweden reported their 100th case on March 4 and on March 6, respectively. Third, the social distancing regime varies strongly between the two countries. Norway implemented restrictive infection control measures at the first wave, whereas Sweden introduced a relatively lenient approach in response to the pandemic. For instance, day-care centers and primary schools remained open. Hence, by focusing on Scandinavia we are able to illustrate a general picture of the first wave of COVID-19.

Compared to the severe recession from the breaking down in housing debt and financial crisis during 2008, the current situation caused by the epidemic is relatively passive due to the risk of moral hazard and human cost, the loss of people’s lives cannot be treated as a simple number and opportunity cost anymore. Identifying the effect of infection control measures is an important piece of the cost-benefit calculus for opening the economy. This study quantifies the extent to which a lockdown refrains the spread of coronavirus through an event study in Scandinavia. A short story analysis of the economic impact of the virus is further developed. In general, we find a short-term public health benefit of Norway’s lockdown and the state has not locked down its economy to the same extent as others.

The remainder of the paper is organized as follows. Section 2 outlines a background which summaries the key facts about the respective public health policies responses to COVID-19 disease issued in their countries. Section 3 offers the literature review which covers the main approaches to control COVID-19 as the pandemic progressed. Section 4 describes the data as well as details our approach. Section 5 presents empirical results with the ensuing discussion, and a number of caveats. Section 6 concludes the overall findings and suggests further studies.

2 Background

In this chapter, the development of virus transmission in Norway and Sweden will be presented. In particular, the different infection control measures provided by their respective public health authorities at the first wave of corona will be introduced simultaneously. Furthermore, the economic measures taken by both governments to mitigate the negative effect of a lockdown as well as the pandemic will be shown later on.

The first detected case of the virus reached Norway on February 26. After a rapid increase in cases and evidence of community transmission, the government issued a series of restrictive infection control measures (i.e., lockdown) on March 12. The same day Norway had its first death due to the pandemic. The population mobility dropped dramatically overnight after the announcement[1]. During the period of lockdown, all kindergartens and schools, physiotherapists, psychologists, hairdressers, swimming pools, and training centers were closed, people who tested positive for COVID-19 were mandated to self-quarantine, foreign nationals who do not live or work in Norway were not allowed to enter or visit it. Sports and cultural events as well as gatherings of over 10 people were banned and restrictions applied to restaurants. Non-essential business and culture institutions were required to shut down, and residents were prohibited from staying in cabins outside their home municipalities, through 13 April 2020[2]. Three weeks later, the Norwegian Health Minister announced that the outbreak was "under control" and the primary schools reopened later on April 28[3], began to ease restrictions slowly and with control. Nevertheless, new cases have started to increase rapidly in Autumn. The public health authority issued new national social distancing measures on November 5 since there was a possible risk of facing a second wave of infection[4]. The new measures were somehow less restrictive compared with the first implementation in the period of the first wave of corona. As of 17 April 2021, Norway reported 106,727 confirmed cases and 708 deaths[5].

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[1] Norwegian Institute of Public Health. (2020). https://www.fhi.no/contentassets/c9e459cd7cc24991810a0d28d7803bd0/covid-19-epidemien-risiko-prognose-og-respons-i-norge-etter-uke-12.--med-vedlegg.-24.mars-2020.pdf/

[2] Norwegian Health Directorate. (2020). https://www.helsedirektoratet.no/tema/beredskap-ogkrisehandtering/koronavirus

[3] Astrup, E., et al. (2020). https://www.eurosurveillance.org/content/10.2807/15607917.ES.2020.25.22.2000921

[4] Norwegian Institute of Public Health. (2020). https://www.fhi.no/en/id/infectious-diseases/coronavirus/

[5] Norwegian Institute of Public Health. (2021). https://www.fhi.no/en/id/infectious-diseases/coronavirus/daily-reports/daily-reports-COVID19/

Table 2.1 reports the dates of the introduction of various measures taken in Sweden and Norway based on Hale et al. (2020). In general, a lockdown can be split into six specific measures against the pandemic. According to Hale et al. (2020), policies from 1 to 6 are classified as 0 or 1, which refers to either they apply only in a geographically concentrated area or they apply throughout the entire jurisdiction. We henceforth refer to March 12 as the 'lockdown' date, as it is the date on which most of the Norwegian restrictions came into place.

For mainland Sweden, the first infected case was confirmed to have reached on January 31 and approximately one month later, the second positive case was confirmed. The first death was reported on March 11 in Stockholm. Unlike most countries, which strongly recommended extensive sector closures and lockdown measures to restrain the spread of the coronavirus disease, the government of Sweden took a more lenient approach to the pandemic. The public health authority has provided several infection control measures, for instance, isolation of individuals with COVID-19 symptoms and tracing of contacts of positive cases. People was advised to avoid unnecessary travels and to keep a physical distance in public as well as to work from home if possible. Although the government was later granted more restrictions on transport following a temporary amendment in April[6], imposing lockdown was considered to be unnecessary by the Swedish authorities. Unlike many European countries, including neighboring Denmark and Norway, Sweden did only close its high schools and universities as a preventive measure. Instead, kindergartens, elementary schools, training facilities and other businesses were kept open, and children's sports continued. In mid-March, the Health Agency recommended that everyone should avoid traveling within the country while the national border was not required to close. At the end of March, the Swedish government applied a general rule against assemblies of more than 50 people to further decrease the spread of the virus[7]. In both countries, people above 70 years were advised to limit social contact and stay at home, as much as possible, aimed to protect its senior and vulnerable citizens.

On December 18, a package of new and tougher restrictions and recommendations were announced in Sweden to curb the cases, including the use of face masks in public transportation, closure of all non-essential public services such as swimming pools and museums[8]. At the

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[6] Regeringskansliet. (2020). https://www.regeringen.se/pressmeddelanden/2020/04/utlandsresor--forlangd-avradan-fran-icke-nodvandiga-resor-till-alla-lander

[7] Swedish Police. (2020). https://polisen.se/aktuellt/nyheter/2020/mars/ytterligare-begransade-mojligheter-till-allmanna-sammankomster-och-tillstallningar/

[8] Löfgren, E. (2020). https://www.thelocal.se/20201218/swedish-prime-minister-stefan-lofven-press-conference-coronavirus/

beginning of 2021, a new pandemic law was passed allowing for the use of lockdown measures[9]. As of 22 April 2021, there have been 938,343 confirmed cumulative cases and 13,923 deaths with confirmed COVID-19[10], surpassing all of its Scandinavian neighbours combined. To limit the spread of the virus, the Norwegian government has introduced strict measures including imposing mandatory quarantine and social distancing rules, whereas Sweden's public health responses to COVID-19 were mostly based on individual voluntary and were instituted more slowly than neighbouring nations.

In addition, there are several financial measures taken by Norwegian government to mitigate the economic effects of the coronavirus crisis as well as lockdown at the first wave of corona. The government issued a loan guarantees for small and medium enterprises while reduced the number of days that employers were obliged to pay salary to workers at temporary lay-offs after adoption. Further, a new scheme for cash pay-outs to otherwise sustainable businesses that were severely affected by measures to contain the pandemic was proposed following a lockdown's enactment[11]. For Sweden, the measures include a postponement of tax payments by all business taxpayer and wage subsidy schemes for short time work employees as well as loan guarantees for companies in the first wave of COVID-19 pandemic[12].

Although Norway and Sweden maintain differences in population density, geography, culture and governmental organization, they have similar ethnic, age distributions of the population, sociodemographic and economic profiles as well as comparable health care systems and public health infrastructures (Juranek & Zoutman, 2020). Despite their respective differences that might have influenced health policy decision-making during COVID-19, these broader similarities between the Nordic countries enable useful comparisons to determine the relative impacts of the differences in public health responses to the first wave of COVID-19 pandemic.

[9] Nordlund, F. (2021). https://www.svt.se/nyheter/inrikes/riksdagen-rostar-ja-till-ny-pandemilag
[10] Folkhälsomyndigheten. (2021). https://www.folkhalsomyndigheten.se/folkhalsorapportering-statistik/statistik-a-o/sjukdomsstatistik/covid-19-veckorapporter/senaste-covidrapporten/
[11] Economic measures taken in Norway are based on Skjesol et al. (2020).
[12] Economic measures taken in Sweden are based on Brokelind & Hansson (2020).

Table 2.1 Timing of the Measures Taken

Measures	Norway	Sweden
1-Schooling closing	March 12 / 1	-
2-Workplace closing	March 12 / 0	-
3-Cancel public event	March 12 / 1	March 12 / 1
4-Close public transport	-	-
5-Restrictions on internal movement	March 16 / 0	-
6-International travel controls	March 15 / 1	March 19 / 1

Note: The 0/1 after the date indicates whether a measure was general (1) or limited in scope (0).

3 Literature Review

In this chapter, previous mass studies that carry out the impact of social distancing policies are illustrated. We begin with the study of measures taken in the US at the first wave of corona since the policies adopted are different from other Western states. Afterward, existing work involving lockdown will be introduced, but the majority is focused on Europe and Scandinavia. Finally, evidence of a lockdown on other health consequences and economic impacts will be presented and dictated solely by interests.

To reduce the spread of COVID-19, the US. has announced a comprehensive social distancing policy adopted is shelter in place orders (SIPOs). It requires residents to remain home for all but essential activities such as purchasing food or medicine, caring for others, exercise, or traveling for employment deemed essential. Between March 19 and April 20, 2020, 40 states and the District of Columbia adopted SIPOs. Friedson et al. (2020) examine the association between SIPOs and COVID-19 cases in the State of California, taking early action to prevent a state-wide COVID-19 outbreak. This study is the first to estimate the effect of SIPOs adoption on health. Using daily state-level coronavirus data and difference-in-differences (DiD) design, the results indicate that California's statewide SIPOs significantly reduced COVID-19 cases by 125.5 to 219.7 per 100,000 population by April 20, one month following the order. After this seminal work, empirical investigations into this relation have focused on whether anti-contagion policies have an impact on COVID-19 cases reduction. Dave et al. (2020) conduct this study using daily state-level coronavirus case data by utilizing DiD approach. They found that approximately three weeks following the adoption of a SIPOs, cumulative COVID-19 cases fell by 53 percent. Still in the US., Berry et al. (2021) show no evidence of SIPOs on reductions in mobility, COVID-19 cases, or COVID-19 related deaths, using daily data collected from February through May 2020 by utilized DiD designs. Nonetheless, they emphasize that the modest effects of SIPOs policies do not imply that the actions of government officials had little effect on the pandemic. There may have been other infection control measures that better mitigated the spread of COVID-19.

Lockdown used to prevent and slow the infection rate is a more rigorous anti-contagion policy compared to the measures taken in the US. It was first implemented in China with the aim of reducing COVID-19 cases and related deaths. Figueiredo et al. (2020) employ an interrupted time series (ITS) design to assess the effectiveness of the toughest lockdown applied in China, using daily data on reported cases and deaths. Their results show a daily reduction of 6.43% in the number of cases and of 7.88% in registered deaths, taking different time lags into effect, suggesting that the effect of reducing cases and related deaths is observed after a period ranging from 7 to 17 days and 10 days, respectively. Still in China, Molefi et al. (2020) identified a 47% decrease in daily reported cases when comparing the pre and post-intervention periods. Besides China, several papers conducted their study in non-European countries in an effort to investigate the effect of mitigation policies. Ghanbari et al. (2020) assess the impact of the non-pharmacological method on COVID-19 in Iran, using daily data and an ITS design. Their results indicate an average decrease of 288.57 on new confirmed cases and 24.67 deaths after adoption. In an experimental study involving 149 countries, Islan et al. (2020) found that enforcing social distance measures reduced the incidence of COVID-19 by 13%. Regarding lockdown, the authors point out that the rapid implementation of these measures promotes an even more significant reduction compared with a delayed implementation.

In most of European countries, a stringent lockdown policy has been declared to enforce social distancing and to prevent the spread of infections. Several analyses were performed in an attempt to understand the impact of nationwide lockdown on COVID-19 cases as well as death rates that have been announced over a period of time. Flaxman et al. (2020) conduct a cross-country study evaluating the effect of five categories of interventions (social distancing encouraged, self isolation, school closures, public events banned, and complete lockdown) for the period from the start of the COVID-19 epidemics in February 2020 until 4 May 2020 in 11 European countries, when the infection control measures started to be lifted. For each sample country, they model the number of deaths, infection cases and R_t[13] which is the effect size from interventions. The modelling approach is used in pooling information from multiple countries at once. Their results demonstrate that only the lockdowns have had a significant effect on reducing transmission and that has a substantial effect of 81% reduction in R_t. Evaluating how lockdown policies affected the spread of the pandemic in Spain and Italy, Tobías (2020) analyzed the trends of incident cases, deaths, and intensive care unit admissions before and after their respective national lockdowns using an ITS approach. They found that incidence trends tend to be declined in both countries after the first lockdown, however, the trends slope were kept rising substantially. After the second and stricter lockdown, the slope of the number of case incidence became negative. In a study involves 12 European countries, Ghosal et al. (2020) found that a significant 61% reduction in infection rates one week post

[13] According to the authors, R_t is time-varying reproduction number. Changes in R_t are an immediate response to interventions rather than gradual changes in behaviour.

lockdown in the overall, using data on infection rates and employing hierarchical clustering analysis. Their results also suggest an exponential decrease in both infections as well as death with lockdown. Still in Europe, Vokó and Pitter (2020) found an average reduction of 0.9% in the incidence of COVID-19 in 28 European countries by utilized ITS approach and data on daily new COVID-19 cases.

By focusing on Scandinavia, Sweden is the only in Europe to avoid some kind of this measure. In light of this, Born et al. (2020) conduct a study to investigate the lockdown effect on Sweden, which is considered as the treatment group, using synthetic control techniques to develop a counterfactual lockdown scenario with daily confirmed data. Their results show that the lockdown effect starts to materialize with a delay of three to four weeks. Nevertheless, infections and deaths in Sweden would have been reduced by one-half and one- -third, respectively, if lockdown was implemented in Sweden. Two Danish researchers, however, proposed different opinions and argued that lockdown might be possibly ineffective. Kepp and Bjørnskov (2021) employ DiD designs to evaluate the efficiency of a lockdown implemented in northern Denmark, Northern Jutland, using daily infection rates from September 1 until November 30, 2020. They found that the extreme version of social distancing measures had a statistically insignificant impact on virus development. Even if the infection rates kept decreasing over time, they actually did so before the mandate was implemented and even before it was announced. Their study suggests that efficient infection tracing and voluntary compliance are more important than actual mandates in controlling infection, at least in some circumstances. This counts as the only study that demonstrates a full lockdown appears to have no significant gains on reducing the number of infections.

Thus far, recent studies present that lockdown measures help slow the spread of COVID-19; there also exist plenty of works investigating the relationship between mitigation policies and other related COVID-19 health consequences. It is vital to see what other health problems would have been incurred during the adoption period. Fiorillo et al. (2020) employ multivariate linear regression models to evaluate the effects of the lockdown on mental health in Italy, using collected survey data. They found that depressive, anxiety, and stress symptoms significantly worsened approximately after two and half weeks when the entire country was placed under a lockdown. In particular, females and individuals with pre-existing mental health problems were at higher risks of developing severe depression and anxiety symptoms. With a focus on well-being, Brodeur et al. (2020) found a significant increase in searches for loneliness, worry and sadness, suggesting that people's mental health may have been severely affected by the lockdown, using daily Google Trends data and DiD designs. Besides, Greyling et al. (2020) conduct a cross-country study to detect the causal effect of infection control measures on happiness by utilizing DiD designs along with a pooled dataset. Their results show that happiness was negatively related to the mitigation policies in South Africa, New Zealand, and Australia. Moreover, they found that South Africa with the most stringent lockdown regulations incurred the greatest happiness costs. Furthermore, Greyling et al. (2021) found that stay-at-home orders have a positive impact on happiness during adoption period while other anti-contagion policies such as non-business closure (e.g., closing restaurants and bars) have adverse effects in South Africa. By using Gross National Happiness Index and DiD approach combined with OLS estimation, their results also suggest that the longer the pandemic has progressed, the more the people with happiness decrease.

Considering the effect of a lockdown on global as well as domestic economy, Verschuu et al. (2021) show that global maritime trade has been reduced within a range of -7.0% and -9.6% during the first eight months of 2020 by utilized advanced econometric models with empirical vessel tracking data. Moreover, they found that global manufacturing sectors were hit hardest, with losses up to 11.8%. With a focus on Europe and Scandinavia, Palomino et al. (2020) found that both poverty and wage inequality rise in all European countries after enactment of either liberal or comprehensive social distancing policies by utilizing advanced econometric models with working ability index. Besides, Alstadsæter et al. (2020) show that younger workers and those with shorter tenure were more strongly affected during the duration of a lockdown in Norway, using data on registered unemployment and fixed-effect models.

The aim of this paper is to assess the effect of lockdown on COVID-19 cases in Norway and Sweden by utilizing DiD design, where one did this policy while the other one did not. Our work contributes to recent research on the effectiveness of government policies on infection during epidemics due to much of the existing work studying the effect of a lockdown in non-Nordic states. Several papers show that non-pharmaceutical interventions reduce infections, or death, using alternate methods (e.g., ITS or synthetic control), we consider the use of DiD designs in this study as another contribution to the existing literature due to its controls for certain types of unobserved time-invariant state/country variables and show a causal effect from observational data if the basic parallel trends assumption is met.

4 Methodology

In this chapter, information on epidemiological and other relevant data related to the measurements will be presented. Additionally, there are two regression models to be estimated. The first model is used to investigate the effect of a lockdown on confirmed COVID-19 cases. After that, the approach to make a sensitivity analysis on the parallel trend assumption will be shown. The second model is used to examine differential effect of a lockdown after certain cut-off period, which is similar to Dave et al. (2020)[14]. At last, the method used to make an analysis on the economic impacts of COVID-19 will be introduced.

4.1 Data

We extracted epidemiological data from the COVID-19 Dashboard provided by European Centre for Disease Prevention and Control (ECDC), a comprehensive data source that is refined and updated each day in a systematic process (Flaxman et al., 2020), which is cumulative daily confirmed cases. The daily confirmed cases were the total number of reported positive cases in Norway and Sweden since the first confirmed case. The date of March 12 was the first day for Norway to implement the lockdown policy, it will be used as an important time node to distinguish between pre-period and post-period. Our data set tracked counties over the course of sixty-three days from the 26th of February 2020 through April 28th, 2020, leading to a sample size of 126 daily observations. We chose February 26 as it is the day of the first confirmed case of infection in Norway. Considering the period for an infection to develop into symptoms is on average 5-6 days, and at most up to 14 days (WHO, 2020), we chose the April 28 end date, and it is also the date on which primary schools reopened in Norway.

We collected state-wide policy data from Hale et al. (2020). There are six specific policy responses to COVID-19, but in this paper, we consider the effect of mitigation policies as a full lockdown. Hence, it was coded as binary variables in Norway, where the policy was coded as either 1 (after the date that the policy was implemented and before it was removed) or 0 (before the policy was announced). For Sweden, the lockdown was coded as 0 under the whole sample period of February 26 and April 28. For control variables, we obtained from the National Climatic Data Center (NCDC), which is the daily highest recorded temperature. We add temperature as an additional control variable since we believe that changes in temperature tend

[14] Dave et al. (2020) use the similar approach to assess the effect of SIPOs on COVID-19 cases in the US.

to have a significant impact on COVID-19 transmission (e.g., Notari 2020, Prata et al. 2020, Shi et al. 2020). For the data used to analyze the economic costs of a lockdown, we gathered from OECD databases, which is seasonal adjusted quarterly unemployment rate as well as relevant GDP growth from January 2019 (pre-COVID-19) to June 2020 (the end of first wave)[15].

Table 4.1 presents descriptive statistics on the aforementioned data separating Norway and Sweden. By the 28th of April 2020, there were a total of 20,168 positive reported cases for COVID-19 in Sweden and for mainland Norway, it reached 7,608. Figure 4.1 plots the daily respective average cumulative cases for countries since adoption. Approximately three months later, the mean reported cases reached roughly 25,000 and 5,000 in Sweden and Norway, respectively. The trend of Norway rose slowly and the slope had seemed to turn flat, indicating that the growth rate of the infections is decreasing, accompanied by fewer new daily cases confirmed within the state. Without imposing strict social distancing policies, infections in Sweden kept increasing while the slope of the trend became steeper, suggesting that a lockdown has a significant effect in limiting the spread of the virus from a data point of view.

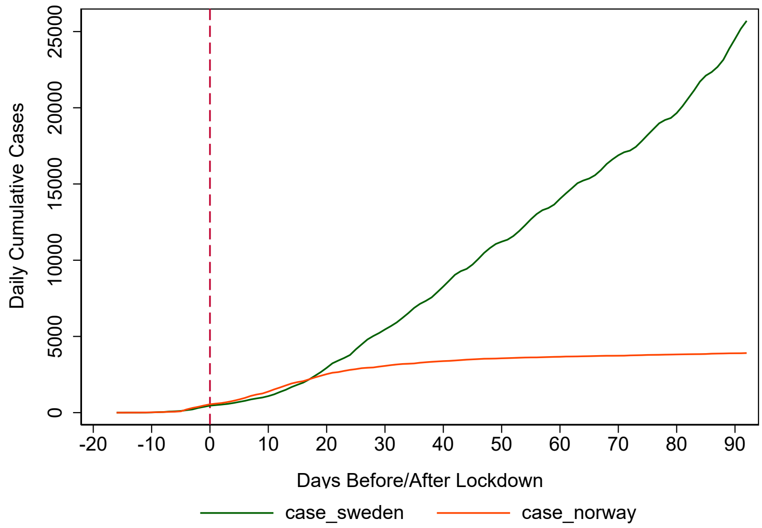
Table 4.1 Descriptive Statistics

Variables	Obs	Mean	Std.Dev.	Min	Max
Panel I: Norway					
COVID-19 Confirmed Cases	63	3723.59	2750.2	1	7608
Temperature	63	-0.27	3.6	-11	4
*Quarterly Unemployment Rate	6	3.84	0.4	3.4	4.6
*Quarterly GDP Growth Rate	6	-0.70	2.2	-4.6	1.7
Panel II: Sweden					
COVID-19 Confirmed Cases	63	6287.67	6398.1	2	20168
Temperature	63	1.52	3.4	-8	8
*Quarterly Unemployment Rate	6	7.11	0.7	6.4	8.5
*Quarterly GDP Growth Rate	6	-1.20	3.2	-7.6	0.5

Note: * refers to seasonal adjusted.

[15] The end of first COVID-19 wave on June is based on Michas (2020).

Figure 4.1 Trend of Average Daily Cumulative Cases after a Lockdown for 90 Days



4.2 Research Design

For our main analyses, we use a difference-in-differences approach to assess the association between lockdown and COVID-19 cases. The fact that governments enact their own policies differently across place and time strongly suggest a difference-in-differences design for estimating causal effects in the COVID-19 (Bacon & Marcus, 2020). It compares changes in COVID-related outcomes before and after a given policy takes effect in one area to changes in the same outcomes in another area that did not introduce the policy. Hence, to estimate the causal effect of treatment (lockdown) on the treated, Sweden serves as our control group, whereas Norway is a treatment group. We use February 26th–March 11th as the pre-treatment period, and March 12th –April 28th as the post-treatment period. We estimate variants of the following model:

$$\mathbf{COVIDCASE}_{ct} = \beta_0 + \beta_1 \mathbf{LOCKDOWN}_{ct} + \beta_2 \mathbf{TMP}_{ct} + \gamma_c + \tau_t + \varepsilon_{ct} \quad (1)$$

where $COVIDCASE_{ct}$ is the count of COVID-19 cases in country c on day t, $LOCKDOWN_{ct}$ is an indicator for the day that Norway adopts a lockdown. With regard to control variables, $TEMP_{ct}$ denotes the daily highest temperature (in degrees Celsius) in the state. In addition, we control for country fixed effects (γ_c) and day fixed effects (τ_t). Model 1 is used to assess the causal effect of a lockdown. Identifying our treatment effect (β_1) via within country variation in the enactment of a lockdown, we would expect the sign of β_1 to be statistically significantly negative, indicating that enactment of a lockdown is effective in limiting the spread of infection.

To interpret the treatment indicator β_1 as the causal effect of a lockdown, we must assume that COVID-19 infections in Sweden reflect how infections would have changed in Norway had they not enacted a lockdown—the common trends assumption. If the common trends assumption fails, then Norway's infections would have changed differently even without a lockdown and β_1 cannot be interpreted as a lockdown effect. If common trends assumption holds, then β_1 gives the causal effect of treatment (lockdown) on the treated. In light of this, a visual inspection of the pre-treatment trends for the treated and untreated states is necessary prior to running the first model. The data of daily cases can be treated as following a parallel trend and satisfy the main assumption of the difference-in-differences approach.

After performing the first empirical model to obtain the causal effect of social distancing policies, a robustness check such as pre-period placebo intervention tests can assess the sensitivity of the conclusions to pre-period trend differences. This is a second way to test the assumption of equal trends. For the placebo model, we assume that a lockdown was imposed on March 4, 2020, and generate a new time dummy which is one for all dates after the date on March 4 (5 March - 12 March), the post-treatment period, and zero for all dates before adoption (26 Feb - 4 March), the pre-treatment period. For the assumption holds, we would expect the sign of β_1 in the placebo model to be insignificant, indicating that time trends in the outcome are the same in treated and control units in the pre-intervention period[16].

The first model is used to examine whether there is a significant impact of infection control measures on the pandemic, after that it is crucial to see how long the policy appears to show its effect in the aim to inform policymakers of an effective adoption period so that the society is not too soon to be reopened in the face of infection risks. To figure out the estimation of post lockdown on COVID-19 cases, we estimate variants of the following model:

$$\mathbf{COVIDCASE}_{ct} = \alpha_0 + \alpha_1\,\mathbf{LOCKDOWN\_1to5}_{ct} + \alpha_2\,\mathbf{LOCKDOWN\_6to14}_{ct} + \alpha_3\,\mathbf{LOCKDOWN\_15to20}_{ct} + \alpha_4\,\mathbf{LOCKDOWN\_21plus}_{ct} + \alpha_5\,\mathbf{TMP}_{ct} + \gamma_c + \tau_t + \nu_{ct} \quad (2)$$

[16] The placebo model is basically like model 1 so we present the model specification here: $\text{COVIDCASE}_{ct} = \beta_0 + \beta_1\,\text{LOCKDOWN\_placebo}_{ct} + \beta_2\text{TMP}_{ct} + \gamma_c + \tau_t + \varepsilon_{ct}$

Model 2 is used to test whether there is a differential effect of lockdown on daily cases after a certain cut-off period. $LOCKDOWN\_1to5_{ct}$ is an indicator set equal to 1 for the period 1 to 5 days following a lockdown adoption, $LOCKDOWN\_6to14_{ct}$ is an indicator for the period 6 to 14 days following adoption, $LOCKDOWN\_15to20_{ct}$ is also an indicator for the period 15 to 20 days following adoption, and $LOCKDOWN\_21plus_{ct}$ is a final indicator for 21 or more days following adoption. Identification of our key coefficients of interest, $_1$ to $_4$ comes from within-state variation in lockdown adoption. According to Lauer et al. (2020), the period from 1 to 14 days is the 99 percent confidence interval for the incubation period for coronavirus. Hence, we would expect the sign of α_1 and α_2 is insignificant, suggesting that the lockdown policy will not affect recorded infections immediately during an incubation period. But we would expect that the policy appears to show its effect after two or more weeks after adoption and therefore the sign of α_3 and α_4 is expected to be statistically significantly negative.

By estimating the aforementioned empirical models, we illustrate a general picture of short-term public health benefits of Norway's lockdown. Moreover, it is essential to figure out whether Norway's lockdown would have incurred greater economic costs in terms of GDP and unemployment rates compared to its counterfactual lockdown scenario. For this purpose, we compare the unemployment rates as well as GDP growth rates in Norway in the first two quarters of 2020 to unemployment rates and GDP growth rates in the control unit in order to analyses the economic costs of a lockdown.

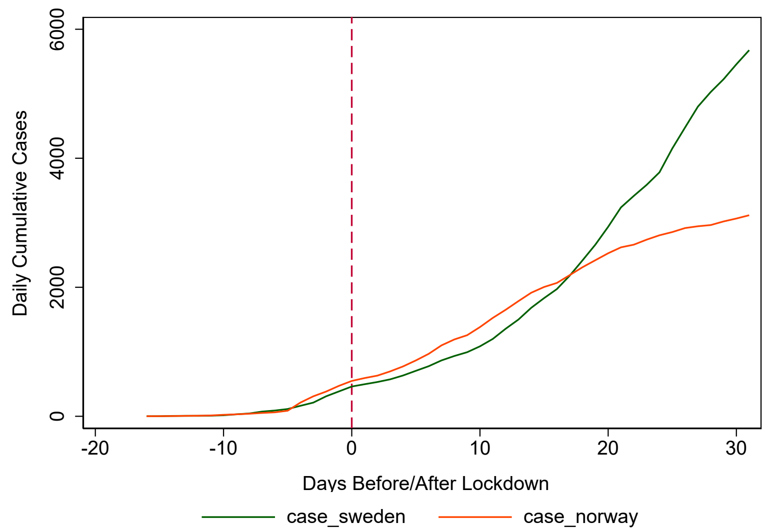
5 Empirical Analysis

In this chapter, empirical results of confirmed COVID-19 cases will be analyzed with ensuing discussion. The economic costs of a lockdown in terms of GDP growth and unemployment rates will be discussed later on. Finally, a number of caveats regarding the study are illustrated.

The parallel trend assumption has to be fulfilled to ensure the internal validity of difference-in-differences models before drawing an analysis of the enactment of lockdown. Namely that in the absence of the measures, the difference in daily confirmed cases in treated and untreated states is constant over time. If the trends differ before the lockdown was implemented, it is likely that some pre-existing differences in the cases between the states are driving the results, not the treatment itself. In this case, the untreated state is not able to provide the appropriate counterfactual of the trend that the treated state would have followed if they had not been treated. Figure 5.1 presents the respective trends in COVID-19 cases for the state with adoption (orange line) and for the state without adoption (green line) under the sample period at the first wave. The trend in daily cumulative cases for the control group is not trending markedly upwards or downwards the period before the implementation of the measures on March 12th. The COVID-19 cases in the treatment group follow a similar pattern as the control group during the pre-treatment period. Several days after a lockdown, the cases began to increase slowly in the treated state while it kept rising in the counterpart. The figure shows a substantial reduction in the cases for the treatment group, suggesting that the social distancing policies have a negative impact on the spread of COVID-19.

Overall, there is a similarity in outcome patterns before the adoption, implying that the number of infected cases in Sweden is able to reflect how the infections would have changed in Norway had they not enacted a lockdown. Besides, the placebo test is performed later on to make statistical analysis on pre-trend treatment.

Figure 5.1 Parallel Trends



5.1 Empirical Results

We begin our coronavirus case analysis with a sample including daily confirmed cases in Norway and Sweden from February 26 to April 28. Table 5.1 shows the means of daily positive cases for Norway and Sweden before and after adoption on March 12. Column 1 corresponds to the average daily cases on pre-March 12 (26 Feb-11 March), and Column 2 presents the data on average reported cases post March 12 (12 March-28 April). Column 3 shows the change in the daily cases for each group, on average. The difference-in-differences estimate on the response to the enactment of a lockdown is displayed in Column 4. The one-month mitigation policies reduced the number of 3,984 reported cases in comparison with the untreated state. This is identical to the difference-in-differences estimate in Table 5.2. Table 5.2 reports the variants of model 1. The first specification (column 1) refers to the baseline regression without the one control variable, the second specification (column 2) corresponds to control for temperature, and the third specification (column 3) is assigned to the placebo test. Based on the first and the second specifications, the coefficient estimate of a lockdown is negative and highly significant, suggesting that a full lockdown appears to have significant gains in reducing the number of infections compared to their counterfactual lockdown scenario. It is essential to point out that the coefficients estimated altered evidently in magnitude as we control for temperature. In fact, it was rising from -11 degrees to 4 degrees and from -8 degrees to 8 degrees in Norway and Sweden between February 26 and April 28, respectively. We would expect the estimated coefficient changes magnitude as we control for this additional variable, which proposes that the predicted variable is correlated with any changes in weather that occurred over time.

Although Figure 5.1 illustrates the parallel trends to highlight that the number of daily confirmed cases for the control group does not change substantially before adoption, a sensitivity analysis on the parallel trend assumption is needed to assess the pre-period trend differences. A placebo test is used to figure out whether the difference-in-differences estimate actually captures the effect of infection control measures on Norway. From the third specification in Table 5.1, we find very little evidence of a systematic difference in the trends between the two groups before the state lockdown; that is, the estimated coefficient is statistically insignificant. That implies the parallel trend assumption would be reasonable in the absence of a lockdown. As a whole, we find that a lockdown reduced the number of infections in Norway by 43 percent, in line with most papers showing that the social distancing policies are effective in containing the spread of COVID-19 disease.

Table 5.3 reports the variants of model 2. This analysis is performed in an attempt to understand the time period on which the policy takes effect. There is little evidence that COVID-19 cases were affected during the initial five days following a lockdown's enactment, and the estimated coefficients on the lockdown policy become much larger after 6 to 14 days. After a 14 days incubation period, the confirmed cases appear to fall in the third cut-off time period but the significance level of the result depends upon the weather controls. In fact, Norway kept a rising trend until approximately 17 days after a lockdown, the confirmed cases in Sweden markedly exceeded it based on Figure 5.1. From both the first and the second specifications, we find that the intervention policies statistically significantly reduced infections for 21 or more days after implementation, indicating that COVID-19 cases began to decrease under the third week, and the policy was effective in reducing infections after 21 days of adoption. This suggests that it takes at least three weeks for the effect of the policy to start to show, in line with Born et al. (2020). Dave et al. (2020) use a similar approach to estimate the effect of SIPOs on the reported cases in the US., found that the COVID-19 cases were not affected evidently during five days following a SIPO's enactment, but the policy appears to show its effect after 6 to 14 days corresponds with a statistical decline in the cases and the health benefits of SIPOs grew larger in the periods following enactment.

Table 5.1 Difference-in-Difference Estimates of the Effect of Lockdown on COVID-19 Cases[17]

	(1) Pre-March 12	(2) Post-March 12	(3) Difference	(4) Difference-in-Differences
Treatment group: Norway	265.18 (64.31)	5001.72 (635.12)	4736.54	
				-3564.02 (961.78)
Control group: Sweden	226.94 (55.04)	8527.50 (982.43)	8300.56	-43%

Standard errors in parentheses

Table 5.2 Difference-in-Difference Estimates of the Effect of Lockdown on COVID-19 Cases

VARIABLES	(1) Cumulative case	(2) Cumulative case	(3) Cumulative case
LOCKDOWN	- 3564.018***	- 4865.453***	
	(961.776)	(1054.043)	
LOCKDOWN_placebo			78.417
			(170.388)
Constant	226.941***	-323.804	27.111***
	(69.679)	(295.269)	(9.689)
Observations	126	126	32
Country and Day Fixed Effects	Yes	Yes	Yes
Weather Controls	No	Yes	Yes
R-squared	0.417	0.511	0.392

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

[17] The DiD estimates shown on Table 5.1 are calculated by hand.

Table 5.3 Effects by Various Cut-Offs Post-Lockdown

VARIABLES	(1) Cumulative case	(2) Cumulative case
1-5 days after lockdown	209.565	159.405
	(163.116)	(170.334)
6-14 days after lockdown	491.098	348.247
	(311.993)	(323.383)
15-20 days after lockdown	-588.110	-832.751*
	(492.924)	(473.297)
≥ 21 days after lockdown	-3213.791***	--3308.361***
	(505.393)	(463.188)
Observations	126	126
Country and Day Fixed Effects	Yes	Yes
Weather Controls	No	Yes
R-squared	0.422	0.508

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

5.2 The Economic Costs of a Lockdown

Although the Norwegian Health Minister announced that the outbreak was "under control" at the first wave of corona after adoption, it is crucial to see the economic impacts of this intervention. Figure 5.2 illustrates the seasonal adjusted unemployment while Figure 5.3 plots the quarterly GDP growth rates of Norway compared to Sweden between January 2019 and June 2020, respectively. With the lockdown policy implemented, the unemployment rate of Norway rose from approximately 3.6% to 4.63%, a roughly 1.03% increase from the first quarter of 2020 to the second quarter of 2020. Looking at its counterfactual lockdown scenario, seasonal adjusted unemployment of Sweden increased from 7.13% to 8.47%, a 1.34% rise between the first and the second quarter of 2020. Besides, we compare unemployment rates in Norway in the first two quarters of 2020 to unemployment rates in the control unit. We find that the unemployment rates in Norway had been -0.1% and 1.2% higher for the first and second quarter of 2020 compared to 2019. In the control unit, the numbers are 0.43% and 2.04%, respectively.

Turning to the GDP growth rate, we find that it had been 1.3% and 4.8% lower for the first and second quarter of 2020 compared to 2019 for mainland Norway. For Sweden, the first-quarter GDP in 2020 declined by 0.6%, while the second-quarter GDP tumbled 7.8% compared to 2019, respectively. Hence, although Sweden conducted itself distinctive from any other countries in that its government opted against a lockdown in the first half of 2020, unfortunately, the evidence of the Swedish economy did not markedly perform better than its neighboring state, which imposed strict social distancing policies. A regression result is performed based on model 1 to estimate the association between lockdown and unemployment rate (see Appendix, Table 1). The monthly data between January 2019 and June 2020 were used due to too few observations given by the quarterly unemployment rate. The result suggests no evidence of a short-run impact of a lockdown on Norway's labor market.

Figure 5.2 Seasonal Adjusted Quarterly Unemployment Rates

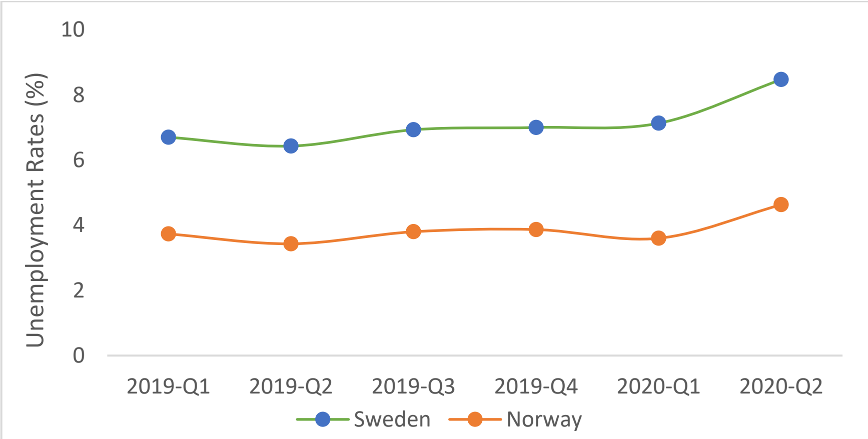
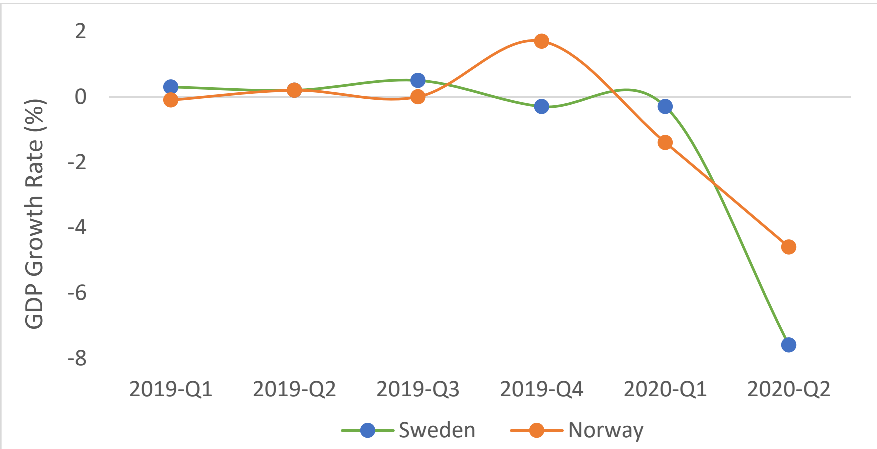


Figure 5.3 Seasonal Adjusted Quarterly GDP Growth Rates



Naturally, as a consequence of closing the non-essential business sectors and travel restrictions, the relevant small or medium-sized enterprises highly dependent on visitor flow rate have paralyzed. There is speculation that the flexible measures which Sweden imposed are mainly aiming at mitigating the effect of above most hit industries. It is valuable to present the particular outcome resulting from the travel ban and business closure. From February to May 2020, the number of bankruptcies in the service sector, tourism and hospitality industry showed a sharp growth of 53% and 76% in Sweden and Norway[18], respectively, almost equally comparable to the record in the 2008 financial crisis. The number of overnight stays is an index specified to the situation of hospitality. This number in Sweden significantly declined since April 2020 compared to the same months of 2019. In detail, over 5.3 million overnight stays were registered in May 2020 roughly 3.1 million fewer compared to the previous year. Correspondingly, in May 2020, only 0.33 million overnight stays were registered in Norway, while there were over 1.97 million domestic overnight stays at the end of May 2019, with 0.75 million recorded as crossing-broad travel. Even though many countries are gradually reopening, the figures for domestic and foreign overnight stays are still maintained lower than the previous year in both two countries.

5.3 Discussion

Our analysis shows that a lockdown reduced the number of infections by 43 percent and a sizable lockdown effect materializes with a delay of three to four weeks. The results are consistent with Born et al. (2020), who study the effect of mitigation policies on the pandemic through an event study on Nordic countries. However, it is distinguishable from Dave et al. (2020), who show that the US. Confirmed cases began to statistically decline from and with the second week following a SIPO's enactment. This can be due to a pre-SIPOs spike in cases. If more people went to markets and pharmacies before intervention was announced and the resulting infections were reported before the SIPO's date, then the confirmed cases may fall soon after adoption because behavior adjustment of individuals raised the pre-intervention infection rate. For Norway, the effects of mitigation policies on infected cases have been delayed for several weeks. COVID-19 Lauer et al. (2020) report a median incubation period of 5.1 days, with 97.5 percent of cases developing symptoms within 11.5 days. The virus' incubation period means that reported infections lag true infections by several days. Therefore, policies that limit exposure will not affect recorded infection rates immediately. Furthermore,

[18] Statista. (2020). https://www.statista.com/

the delay with which a lockdown effect becomes visible not only because of the incubation period of COVID-19 but because of the time span between infection and testing.

The full lockdown for a month can be seen as an effective measure against corona through the case of Norway. On the one hand, it gives sufficient time to stem the cases on the other hand; the shorter adoption period would have contributed to less economic costs. It could, however, take a longer period for states with higher population densities to keep the cases "under control" because high population density catalyzes the spread of COVID-19 as it increases contact rates (Rocklöv & Sjödin, 2020; Dorward et al., 2020). In fact, France introduced an approximately two-month adoption period while Italy issued an even longer duration lockdown for almost two and half months. Hence, COVID-19 cases might be spiked again if policymakers are too soon to ease the restrictions and reopen the economy. With considering an incubation period of 6 to 14 days and state demographic characteristics, the need to further prolong the adoption period has to be reviewed and examined carefully. Norway issued new and more strict social distancing policies in November and declared a second lockdown in Oslo which lasted for several weeks to hasten the spread of the virus at the second wave of the corona.

Through the research and analysis of the above empirical model from the case of Norway, the extremely severe city lockdown measures indeed effectively prevent the spread of the virus and control the infected rate during the early outbreak period; also the trade-off of increase in the pressure on the national economy could be relatively smaller than expected. According to Skjesol et al. (2020), the Norwegian government took several financial measures to mitigate the negative effects of interventions and pandemics on the economy and mostly on the labor markets. Nevertheless, there was a counterfactual scenario in Sweden, perhaps government's recommendations offer guidance to a voluntary social restraint and leading the adjustments to individual behavior, with an invisible reduction in people's wealth as well as their willingness of consumption and travel, the destroy to GDP, business recession, and the labor market is literally inevitable. Even if Sweden has not locked down its economy to the same extent as others, the GDP contraction in the second quarter of 2020 was mainly driven by a significant decline in exports (Bricco et al., 2020). However, both countries experienced an economic expansion in the third quarter of 2020. By providing social protection of financial parts of both employers and employees, some of the temporary job losses may rebound and hence GDP once the lockdown is lifted and the risk of infection weakened. Furthermore, after the overwhelming majority have induced lockdown, whether Sweden implements lockdown or not, it can hardly manage itself alone without being influenced by any negative impact from the global economic environment. Vitally, the sizable results suggest that a lockdown policy in Norway with the main goal of protecting residents from being infected assembly is quite reasonable to be implemented.

Overall, this paper finds that a lockdown contains the spread of COVID-19 infections and the results largely demonstrate a short-term public health benefit of Norway's lockdown. Furthermore, it takes time for this effect to materialize. The logic behind lockdown is to mandatory adjust peoples' behavior to reduce their social interactions in ways that limit the spread of the virus, and hence stem the rate of infection. Compared with Norway, Swedish citizens were advised to keep social distance in public; in other words, people were taken voluntary social restraint. They had much more infected cases than Norway at the first wave of the corona, suggesting that the actions of the Swedish government had little effect on the pandemic, and Swedish policies against corona did not reduce COVID-19 cases as much as Norway policies did. There may have been other infection control measures that better mitigated the spread of COVID-19. The main justification for this study is that the enactment of strict social distancing policies seen to be more efficient in comparison with a relatively lenient approach in the face of infection risk. This study also focused on the short-term impacts of policies, the long-term benefits of a lockdown might be incurred substantial economic costs and hence, it could be reviewed as a temporary measure against contagious diseases. The development of a vaccine or effective treatment for COVID-19 is a way to gain long-term effects. In particular, it cannot be ruled out that some of the COVID-19 cases and related deaths may be postponed to the near future when the lockdown is lifted. In that case, to prevent virus transmission and serious illness by providing sufficient beds, ventilators, and medical professionals are viewed as the most likely path to yield long-run public health benefits.

There are a number of caveats that should be pointed out before concluding. The data on COVID-19 confirmed cases are used to assess the effect of mitigation policies, but we cannot make our analysis in the absence of assumptions that many infected individuals were not accounted for and asymptomatic individuals were less likely to get tested. Therefore, the daily cases used may be underestimated. This paper analyzes the effect of a full lockdown, specific lockdown measures; (e.g., school closure, non-essential business closure, etc.) may differ in terms of effectiveness. Besides, our study converted only the lockdown policy to 0–1variable to simplify the modelling and data analysis. Additional stringency levels, which could be defined by whether the specific lockdown measure is implemented in general or limited in scope, could greatly increase the total amount of policy variables. Moreover, there is an issue of external validity when using a difference-in-differences approach. We cannot be sure that the results can be generalized to and across other contexts and countries. It is also crucial to mention that the behavioral adjustment in Norway might be influenced by other European countries that imposed a lockdown.

6 Conclusion

In this article, we first provided sufficient background information on the epidemic situation and the latest daily statistics to build a foundation of investigation, focusing on the first wave of epidemic closure in two countries with broader similarities but announced different policies against the COVID-19 pandemic. Secondly, data on coronavirus cases from February 26, 2020 to April 28, 2020 and a difference-in-differences approach were used to conduct the empirical analysis. We find that there was a significant negative association between the statewide lockdown policy and the number of infected cases. The result is particularly significant after the medically defined two-week incubation period. It is therefore important to emphasize that the established Norway's lockdown strategies are proved to be reliable in limiting the virus transmission. Finally, the economic situation in both countries experienced large contractions in terms of economic growth as well as labor markets in the first half of 2020 but Sweden that has not locked down seems to be more affected by the pandemic. In summary, in the face of threats and challenges in public health event, especially in countries with a low population density similar to the research object of this article and a geographical advantage from the original epicenter, the government can buy precious time to contain the spread of the virus by adopting a lockdown policy at the early stage.

In general, this study focused on the short-term impacts of policies that can effectively and temporarily reduce the number of infected cases. The effect of long-run horizon policies warrants future research because of changes in the virus variants, spillover effects across states, and other factors. Besides, further study is preferable to forecast the reduction in infection if a lockdown is further continued. This is a way to inform policymakers how effective the prolonged lockdown is so that they do not maintain restrictions for too long, hampering economic and social recovery. Even if policies are effective in limiting the virus spread, the effects of measures may not be shown immediately on reported outcomes. Policies with null short-run effects, on the other hand, do not certainly imply that they have no impact on the pandemic. It is hence essential to understand and figure out the heterogeneity in the effect of public health measures. On the whole, this analysis gives the government that imposed lenient approach against the virus an objective prospect of dealing with a global pandemic situation and provides guidance on current lockdown measures in Nordic regions and, subsequently, helps improve public health intervention strategies against the pandemic on country and global levels.

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Appendix

Table 1. Difference-in-Difference Estimates of the Effect of Lockdown on Monthly Unemployment Rate

	(1)
VARIABLES	Unemployment rates
LOCKDOWN	-0.786
	(0.468)
Constant	7.007***
	(0.173)
Observations	36
Country and Month Fixed Effects	Yes
R-squared	0.624

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.