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The Cost of Being Unprepared or the Benefit of the Precautionary Principle?

Comparing Cost-Benefit COVID-19 Policies and Outcomes in Scandinavia.

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Abstract

The Scandinavian countries of Denmark, Iceland, Norway and Sweden have approached the first months of the 2020 novel coronavirus pandemic with a range of economic and health policies that have resulted in disparate outcomes. Though similar in behavioral norms and institutions, Denmark, Iceland and Norway chose a precautionary approach that formally shut down schools and businesses to protect human health, while Sweden took a Business-As-Usual (BAU) approach aimed at maintaining normal economic and social activities. Iceland and Denmark have further invested in testing, tracking and containing the disease. Economic costs of the pandemic and government fiscal and monetary interventions to reduce their impacts have been dramatic and similar across countries, while Sweden has had the most severe loss of life. Using a panel from the four countries since the beginning of the pandemic, we calculate lives saved from stricter interventions by estimating cases and deaths as functions of behavior and government interventions with a bioeconomic model, then estimating the additional lives lost if these interventions did not occur. Comparison of the countries reveals three important lessons for both policies aimed at the pandemic and broader goals with high uncertainty levels: (1) the precautionary approach can be lowest cost, while still expensive; (2) detection and monitoring (e.g. testing and tracking) are integral to a successful precautionary approach; and (3) expecting tradeoffs between economic activity and health creates a false dichotomy – they are complements not substitutes. Pandemic policy should focus on minimizing expected costs and damages rather than attempting to exchange health and safety for economic well-being.

Keywords:

COVID-19 Pandemic; precautionary approach; Scandinavian policy responses to COVID-19 pandemic; Denmark; Iceland; Norway; Sweden; impacts of COVID-19 testing

1. Introduction

This paper uses data for the Scandinavian countries to roughly estimate the net expected benefits of the policies in place across the region to address the novel coronavirus pandemic, and tradeoffs amongst the different policies in place. With extremely high levels of uncertainty, the policy differentials are coming to represent potential under-intervention (Sweden), potential over-intervention (Denmark and Norway), and the estimated benefits of increased information and testing (Iceland and Denmark). With similar cultures and institutions but differing current approaches to the pandemic, the Scandinavian countries provide an opportunity to investigate how policy differences might be expected to affect the economic and social outcomes from the virus in the short and longer run.

Recall that initial arguments for the shutdown of economic activities focused on ‘flattening the curve.’ This was intended to alleviate critical anticipated shortages in protective gear (PPE) and hospital beds, equipment and staff, and to buy time to remedy a lack of ability to quickly test, trace, and isolate. The losses from months of dramatically reduced economic activities have been significant and immediate, and not without controversy. The Danish Prime Minister, Mette Frederiksen, has had to defend her government’s “extreme precaution” policy, under which the Health Authorities were told to ignore ‘proportionality’ concerns in regulations for the sake of public health and safety (Ritzau, 2020a), where proportionality refers to the normal way in which Danish regulations must consider the full consequences of government action rather than only health or economy, for example.

In contrast, perceived preparedness, in terms of adequate investment in scientific knowledge, facilities, testing and tracking, and gear, may have minimized some economic losses by keeping social and economic activities more open. This openness has also not been uncontroversial. Sweden has experienced significantly higher infection and death rates, which they have defended as a ‘sustainable’ long run investment in overall societal well-being due to the expectation that it will be a long time before a vaccine or cure can be ready (Ritzau, 2020b). This ‘sustainability’ is more in line with the Danish business-as-usual (BAU) than proportionality would have been. Thus, the two countries’ responses represent a precautionary principle approach (Denmark) vs. a BAU risk management approach that focuses more on the known-unknowns (Sweden) and health advice rather than behavioral mandates.

For Iceland, Norway, and Denmark, we calculate estimates for lives saved for the first months of the pandemic from stricter measures relative to the Swedish experience. We contextualize this analysis with greater understanding of behavioral changes tracked with Google Mobility data and of preparedness perceptions with data on hospital capacities. We also track expected economic losses in GDP for 2020 as forecasted at different points in the pandemic, contextualized with information on government interventions to understand how expectations and costs have unfolded as consequences become evident over time. We find evidence that the precautionary principle approach has had greater payoffs than BAU risk management and suasion alone.

2. Background and Literature

At the four-month mark, there has been a turning point in strategies and a measurable divergence of outcomes that justifies evaluation of these early decisions, despite high remaining levels of uncertainty. The uncertainties are great for both epidemiological and economic consequences of the decisions. Global insurance markets, for example, remain uncertain how to handle the changes, with a large outstanding legal question regarding the extent of liability for business disruptions in a global pandemic (Chester et al, 2020). Stock markets have crashed and recovered, with high volatility remaining. There is some evidence that ESG stocks - those investing according to Environmental, Social and Governance principles - have fared better than the broader market (Albuquerque et al, 2020), supporting our understanding that choices aimed at resilience and precaution that avoid external damages can pay off. The long-term effects of the disease, particularly in younger people, remain unknown while continuing investigations provide a wide range of concerns, also promoting an interest in avoiding long term downside risks.

Sweden’s position as a policy outlier due to its refusal to issue lockdown orders has garnered significant research and lay interest. Born, Dietrich and Mueller (2020) and Cho (2020) each create a counterfactual “Sweden” out of composites of other European countries to analyze the effects of the non-pharmaceutical interventions available to Sweden but unused; they find opposing results. Born et al (2020), published with data for only the first month of the crisis, suggest that lockdowns would not have given Sweden any significant additional benefit. Soo (2020), with later data available, finds the opposite. Sweden’s government and epidemiological team have argued from the start that there is a need for long term strategy (Prime Minister’s Office, 2020), and assessments moving forward may indeed reflect a back-and-forth in measures of success over the next year or longer in the search for a vaccine or cure. However, the significant re-openings of Denmark, Iceland and Norway suggest that there have been important opportunities to reduce the impacts which Sweden lost in the early days of the pandemic. Sweden itself has determined, as of July 8th, that some policy revision may be needed (Ministry of Health and Social Affairs, 2020a) and has also launched an investigation into the early handling of the pandemic (Ministry of Health and Social Affairs, 2020b), though the investigation's results are not expected until the end of February 2022.

The pandemic seems to have eased significantly, at least temporarily, in Denmark, Norway and Iceland. A slow restarting of economic activities begun mid-April has been gaining momentum. This has occurred so far without significant increases in cases or deaths; combined COVID-19 deaths by June 30, 2020 for the three countries number 865 (Table 1) and new cases per 100,000 residents per week are now below 5 in all three countries (Table 1). On June 15th these three countries plus Germany began allowing mostly unrestricted travel again, and further unrestricted EU travel became possible July 1st. Sweden, on the other hand, with whom full open borders will not recommence for the time being, has had the highest national rate of new cases per capita amongst Northern, Southern and Western European countries since week 22 (May 24-30).

Table 1: COVID-19 Disease statistics for Scandinavian Countries through July 1, 2020.

Country	Confirmed Cases (01/07/20)	Attributed Deaths (01/07/20)	Cumulative deaths per 100,000 residents (01/07/20)	Cumulative Cases per 100,000 residents (01/07/20)	Cases per 100,000 residents, week 11	Cases per 100,000 residents, peak (week)	Cases per 100,000 residents, week 26	Cumulative Tests per 100,000 residents (01/07/20)*
Denmark	12,768	605	10.445	220.434	13.51	35.67 (15)	4.9	18,661
Iceland	1,842	10	2.93	539.78	21.24	138.04 (13)	3.81	18,503
Norway	8,865	250	4.611	163.523	9.59	34.73 (13)	1.86	6,039
Sweden	68,451	5,333	52.806	677.782	6.3	73.53 (26)	73.53	5,151

*latest testing data from Sweden is 28/06/2020; latest testing data from Iceland is 13/06/2020.
Sources: worldometers.info (tests per 100,000 inhabitants) and European Center for Disease Prevention and Control (remainder)

2.1. Effects of intervention on epidemiological outcomes for COVID-19

Epidemiological-economic modeling for COVID-19 is proceeding rapidly. Most of these models currently rely on a parameterized S(E)IR (Susceptible-Exposed-Infected-Recovered/Removed) model in a dynamic optimization framework (Eichenbaum et al, 2020; Flaxman et al, 2020; Thunstrom et al, 2020; Greenstone and Nigam, 2020). The models have varying degrees of detail for both economic and demographic-epidemiological parameters, but few have so far included human behavioral responses directly in the assessments of economic costs and benefits. Moving forward, more emphasis is likely to be placed on such behavioral responses as we come to better understand the impacts of decentralized decision-making under social-distancing (Cornell

Atkinson Center for Sustainability, 2020) and the role of super-spreaders (e.g. Sneppen & Simonsen, 2020). For our purposes, we use Google Mobility Data to explore behavioral changes. Furthermore, high levels of trust in Scandinavia (Andersen, 2017) may minimize any distortions of modeling without formal accounting for behavioral responses, which we must do to include Iceland. This is because most citizens readily follow the advice of government and medical professionals; this assumption is confirmed for the pandemic with the Google Mobility Data (see section 3.4).

We have examined in close detail the Imperial College London epidemiological method described in Flaxman et al, (2020) and find that even the state-of-the-art epidemiological modeling is fraught with overly simplified assumptions of both the transmission of the disease and the efficacy of policy. These simplifications generate great uncertainty in the unchecked potential of this pandemic and have lent themselves to generating large estimates of the magnitudes of savings. We have run their shared program code with updated country-specific data and the addition of Iceland through June 3rd, 2020 to discover that their model, while replicable, produces unreasonable results when just a few weeks are added to the analysis and also does a poor job of explaining Iceland's pandemic experience. In short, with their model, without lockdown interventions, more Europeans would have COVID-19 by this time than exist.[1] Their estimates that suggest there were millions of lives saved in 11 European countries by early May, generated by the assumption that the disease would have spread unchecked at high reproduction rates (~3.8 for the Scandinavian countries) are not convincing for the longer term. Our model uses the Swedish case as the counterfactual, thus avoiding the need to make heroic assumptions about deaths avoided as the pandemic has unfolded.

2.2. Effects of intervention on economic outcomes for COVID-19

Like Flaxman et al (2020), economists' research on the net benefits of social distancing has produced large estimates of benefits. Thunstrom et al. (2020) and Greenstone and Nigam (2020) both found that in the US case, social distancing measures should save the US economy over $5 trillion in losses, mainly due to avoided loss of life from 'flattening the curve' and overwhelming scarce medical resources. Eichenbaum et al (2020) dive further into the US economy with a more thoroughly defined SIR-model coupled to a macroeconomic model with both aggregate demand

[1] We are not alone in noticing the significant limitations of this model, as the comments on the Nature website pertaining to it attest.

and supply effects. They also found ‘doing nothing’ to induce social distancing should result in tens of trillions of dollars in net losses to the US.

These papers, released at the beginning of the pandemic in the US, in March 2020, focus mainly on the statistical value of saved lives (VSL). Their mean estimates of economic damages are now lower than current estimates of the magnitude or duration of the economic consequences for the U.S., where about 40 million people have filed for unemployment benefits in the last 2.5 months.[2] Recent estimates from the Congressional Budget Office (CBO) place the expected reduction of GDP in the US in double digits for 2020, and requiring a decade to recover to 2019 levels (CBO, 2020). Furthermore, as US workers often receive health care benefits through their place of employment, additional health risks may be accruing from the unemployment, compounding the problem. Government schemes to support workers have been both unprecedented in magnitude and insufficient to cover the losses Americans face (Parrott et al, 2020). At the same time, over 140,000 persons have died from the coronavirus in the US, providing a rough estimate of 1.3 trillion US dollars in losses at a current VSL of $9.3 million (Eichenbaum et al, 2020). Epidemiologists have now estimated that these US figures could have been 40% lower if social distancing mandates had taken effect one week earlier in March (Pei et al, 2020). With numbers of US cases rising dramatically again, the call for new social distancing requirements and lockdowns is growing, including from the director of the National Institutes of Allergy and Infectious Diseases, Dr. Anthony Fauci (Linebaugh and Knutson, 2020). The significant economic costs that have already been paid will have been almost complete losses if greater control is not established over the pandemic. This is an important lesson that the Scandinavian experience highlights in cross-section rather than time series. Swedish economic gains appear to be virtually non-existent compared to the other Scandinavian countries; there has been little if any positive tradeoff in purely economic gains.

Furthermore, since labor and health markets in Scandinavia operate differently from the US, with e.g. national health care and flexicurity (Barth et al, 2014), and government interventions have funded schemes to keep workers employed, the overall economic consequences in the region have been borne more broadly by government spending and borrowing than by individuals; this may defer more costs to future years but has maintained considerable economic continuity in spite of social distancing-imposed closures and restrictions. Neither the economic nor

[2] This likely does not include significant numbers of e.g. informal workers in tourism who are not eligible for unemployment.

epidemiological outcomes in Scandinavia have been as dire as in the US. These are broader lessons to preparedness and resilience.

Economic forecasts have varied within and across locations, reflecting unprecedented uncertainty about the local and global effects of COVID-19 interventions. The breadth of estimates, also in comparison to the beginning of the year and in the weeks following the WHO's first public notification of the COVID-19 disease spreading in Wuhan Province, China, on January 12th, is shown in Figure 1 (See Appendix 1 for summary and sources). In January 2020, all four countries were expecting modest growth between 1-2%, with consensus across a variety of sources. Since new estimates started to surface from mid-March, all countries are predicting declines in GDP for the year, but there remains little certainty about the magnitude of those declines. Between the BAU forecasts at the beginning of the year and the spring estimates, all countries experienced their first COVID-19 cases (dash-dotted lines), and all had issued varying degrees of restrictions on movement and recommendations for social distancing.

Table 2: Restrictions and Social Distancing Policies

	Denmark	Iceland	Norway	Sweden
Border Closures	3/13 -6/27*	3/16-6/15*	3/12-8/20*	3/18-6/15**
Testing for visitors	Yes	Yes	No	No
Mobile Contact Tracing App Start	6/18	4/1	4/18***	4/29
Event Prohibitions	Yes	Yes	Yes	Yes
Max. number (most restrictive)	10	10	5	50
Max. number (July 10)	50	500	50	50
Start Date	3/13	3/16	3/12	4/29
School Closures				
Primary (gr K-5)	3/11-4/15	3/16 - 5/4**	3/12 - 4/27	none
Middle (gr 6-10)	3/11- 5/18	3-16 - 5/4**	3/12 - 5/11	none
Gymnasium (gr 11-13)	3/11-6/8	3/16 - 5/4*	3/12 - 5/11	3/17-6/15**
Universities	3/11-6/22*	3/16 - 5/4*	3/12 - 6/15	3/17-6/15**
Business restrictions:				
Health and Personal Care	3/13-4/15	3/16 - 5/4*	3/12-4/27*	independent
Retailers	3/13 - 5/11**	3/16 - 5/25*,**	3/12-4/27*,**	independent
Restaurants	3/13-5/18**	3/16-5/25*,**	3/12-5/11**	independent^
Cultural activities	3/13-5/27	3/16 - 5/4	3/12-6/15	independent

*partial lifting

**partial openings throughout

*** App use banned June 15 citing privacy concerns

^ distancing regulations and liabilities changed in SE July 1, increasing requirements

The timeline in Figure 1 and dates summarized in Table 2 mark the periods during which the major restrictions and behavioral advice were announced and implemented by each country as the period between solid lines for each country (Denmark in red, Norway in gray, Iceland in blue, and Sweden in yellow). As is well known, Sweden has had the least direct economic interventions. The country also took the greatest amount of time to issue recommendations and to implement the few restrictions on some gathering sizes and some school closures, with first recommendations as early as March 11th and the closure of gymnasiums (high schools) on March 27th. Denmark announced dramatic restrictions, also on March 11th, but these would come into effect by March 13th, including travel restrictions to and from other countries. Norway's restrictions were announced a day later, with immediate effect, though there were a few additional days before the travel restrictions commenced. Iceland, which had a jump on testing that began at the end of January, took longer than Denmark or Norway to implement fewer overall restrictions. Denmark and Norway used the lockdown period to increase testing capacities. While gradual openings started before the full effect of increased testing capabilities came online in early May, most testing and tracking implementations were in place before students older than about 11 returned to schools, and adults to work, from mid-May.

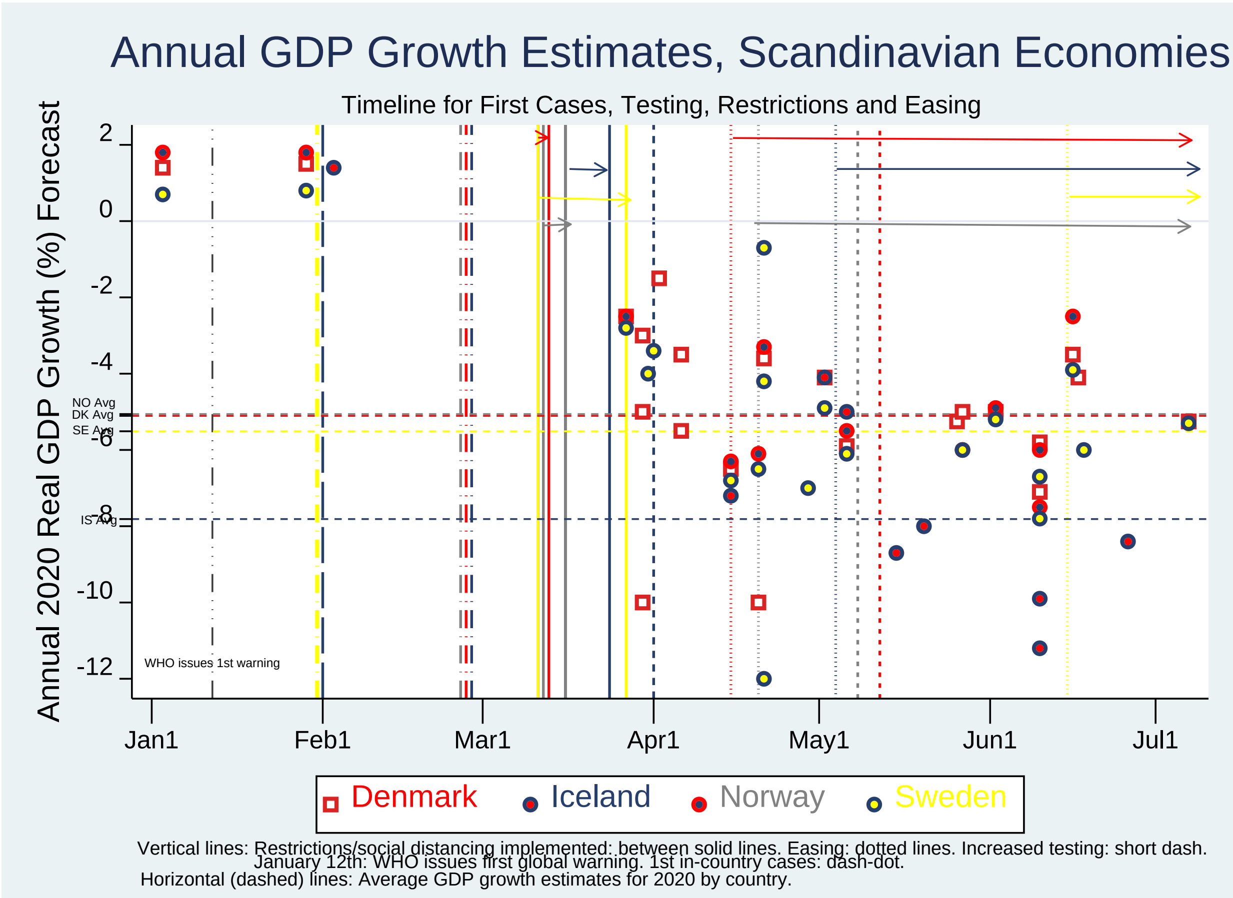

Figure 1: Estimates of GDP growth in 2020 over time

The figure includes the average forecasts for GDP losses in 2020: Denmark and Norway at 5.1% of 2019 GDP, Iceland at 7.8% of 2019 GDP, and Sweden at 5.5%. The Icelandic economy is highly dependent on foreign tourism, accounting in large part for its higher expected losses. Sweden's openness has not protected the forecasts for economic growth.

3. Model and Data

3.1. Model

We first model how many cases a country will have at a given time, as a function of their current caseload and the non-pharmaceutical interventions and behavior. We do this using a logistic growth SEIR approach, so that:

New cases = fn (total cases, country specific non-pharmaceutical interventions, carrying capacity, behavioral responses)

We then model the probability that these cases translate to deaths per 1000 people for each country. The mortality rates may differ due to formal interventions promoting social distancing, knowledge of illness (testing), and by fixed effects including hospital capacities, so that:

New deaths per 1000 people = fn(previous case rates, previous testing rates, country specific non-pharmaceutical interventions and hospital capacities, behavioral responses)

We use these models and panel data from March through early July 2020 pertaining to cases, deaths, testing and hospital capacities, mobility patterns and country-specific non-pharmaceutical interventions to estimate expected cases and deaths for each country. With these sets of estimates, we cast conditions in Denmark, Norway and Iceland to Swedish conditions to estimate how many cases and deaths have been avoided through stricter social distancing requirements.

3.2. Pandemic Preparedness

In 2019, for the first time a Global Health Security Index ranked countries for their pandemic preparedness (GHX Index, 2019). The index considers 34 indicators aimed at comparing prevention, detection, response, health, norms and risk preparedness for pandemics. Table 3 shows how the four Scandinavian countries ranked, as well as their scores.

Table 3: Pandemic preparedness figures

	Denmark	Iceland	Norway	Sweden
GHS Index Score (out of 100)	70.4	46.3	64.6	72.1
GHS ranking (out of 195 countries)	8	58	16	7
Hospital beds per thousand people	2.5	2.91	3.6	2.22

The index correctly assessed that no country was particularly well prepared for a pandemic. It also suggests Sweden and Denmark were viewed as relatively more prepared for the pandemic than most other countries, including Iceland and Norway. The breadth of the preparedness index did not enter the political debate regarding whether to shut down or not, however; this focused almost entirely on the number of ICUs and respirators.

The overall Swedish and Danish preparedness indicated by the index is not well-reflected in hospital beds per 1000 people (Table 3). Sweden had the lowest number, at 2.22 per 1000 people, while Norway had the most, at 3.6 per 1000 people. As mentioned, the focus of most social distancing policies was to flatten the curve in order to not exceed the capacity of the health care system. One of the most critical aspects is the availability of intensive care units (ICUs). Figure 2 shows the total capacity of directly available ICUs as estimated by the different authorities in Denmark, Norway and Sweden, as well as the number of people occupying these units.[3] Sweden has had a larger number of people in intensive care (IC), and actually has exceeded their direct capacity, whereas Denmark and Norway have not come close to capacity.

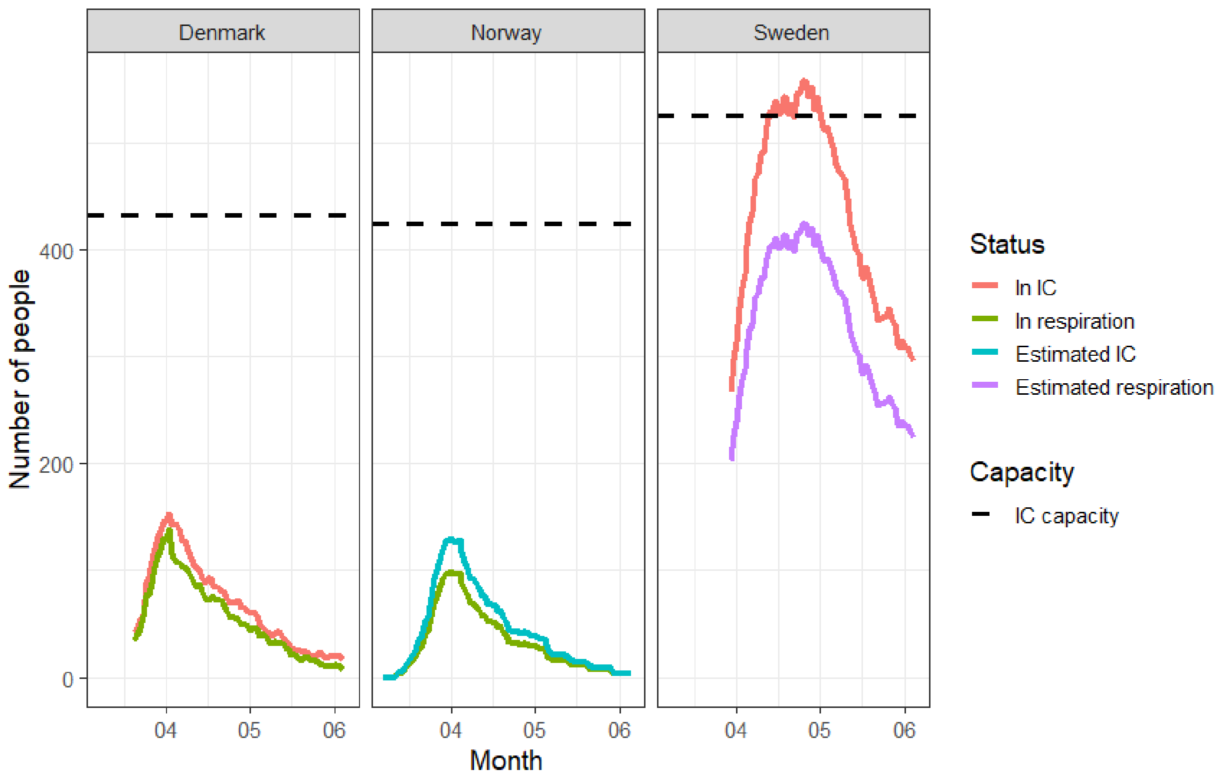

Figure 2: Number of people in intensive care (IC) and in respiration. For Norway and Sweden respectively the number of people in IC and in respiration were not directly available; they have been estimated based on the mean percentage difference in Denmark. Supporting data in Appendix 2. Sources: Danish IC and respiration: Statistikbanken, capacity: Sundhedsstyrelsen, Norwegian data: Helsedirektorat, Swedish IC data: Svenska Intensivvårdsregistret, Swedish capacity: Sjödin et al., 2020.

Given that these are absolute numbers it is not surprising that Sweden has a larger number of people in IC than Denmark and Norway, as Sweden's population is roughly twice as large as that of Denmark or Norway. However, the absolute IC peak in Sweden is 3.6 times the number in Denmark, so even after accounting for differences in population the number of people in IC is

[3] Figures for Iceland could not be located, but capacity has not been exceeded.

significantly higher. Also, the duration of the peak seems to be longer in Sweden. Despite the continuing climb in deaths in Sweden, IC and ventilator use have declined into July.

3.3. Policy Interventions

In this section, we compile the economic and non-pharmaceutical measures taken in the four countries as recorded by the IMF (IMF, 2020a). These show that all four countries have taken extensive monetary and fiscal policy measures (Tables 4 and 5 and Figure 5) to counter the economic effects of the virus, and again that Sweden has not had reduced costs in this dimension.

3.3.1. Non-Pharmaceutical Interventions

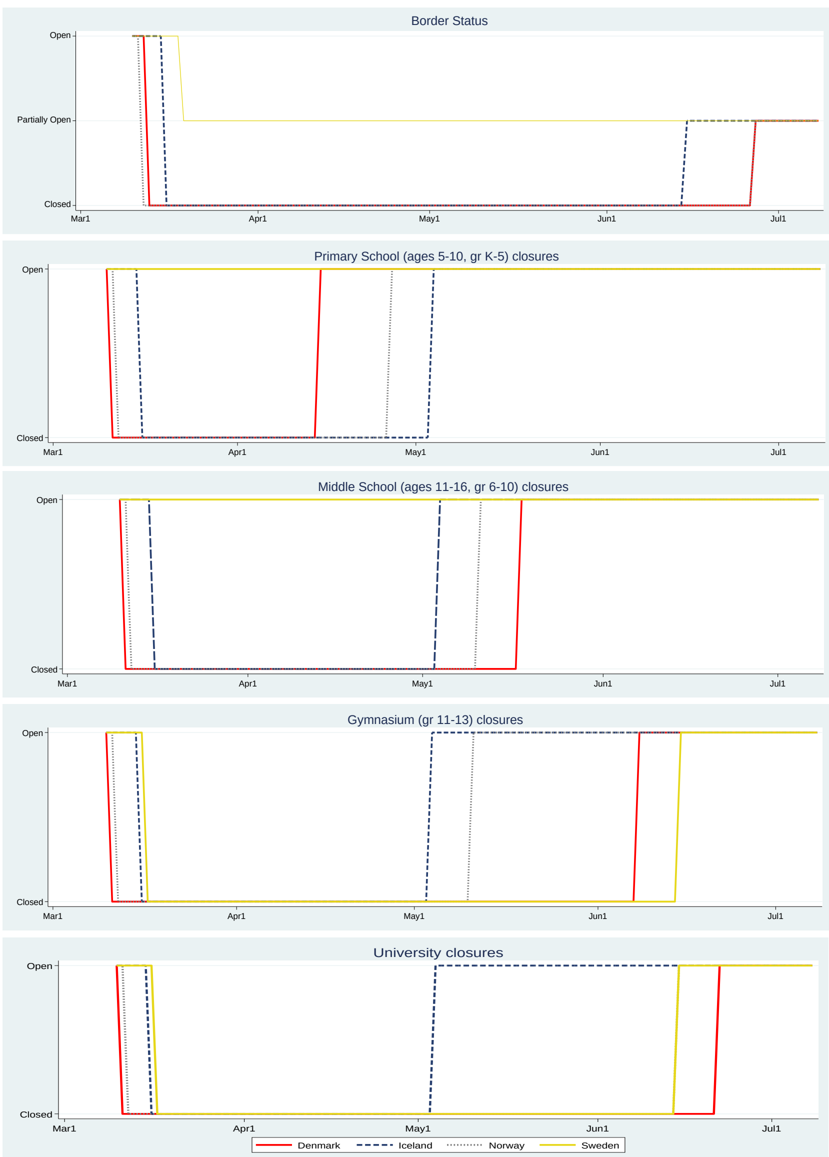

Figure 3: Border and School Closings Since March 10, 2020.

3.3.1.1. Closures (Lockdowns)

Sweden kept borders and schools more open, as visible in Figure 3. Given that we have learned that children do not exhibit illnesses as frequently or as intensely from COVID-19 infection (Lee et al, 2020) and may not transmit the virus as easily, or at least are no more likely as adults to transmit it (Rajmil, 2020), and there were no significant spikes after primary schools reopened, it is possible that by not closing primary schools, the main impact has been that parents did not stay home with them. The school closures may well have enforced adult distancing more than directly influenced the reduction in spread through their actions.

3.3.1.2. Testing

The testing strategies of the countries provide the detection and monitoring necessary to complete management of the pandemic at low levels of spread and to maintain the benefits of the precautionary approach. They have been quite different from one another (Figure 4). Iceland was quick to scale up testing, and the country was able to use a broad testing strategy to effectively identify and isolate cases quickly; deaths on the island nation have been limited to 10. Additionally, the information from Icelandic testing has informed the world about the high levels of asymptotic carriers and the spread of the disease (Gudbjartsson et al, 2020), creating significant positive externalities for the world's battle against the virus. In Denmark, Novo Nordisk has contributed financial and technical support worth tens of millions of dollars to increase testing (Novo Nordisk Fonden, 2020). This investment has significantly increased testing capacities in the country; testing has gone from requiring significant symptoms and a doctor's approval to access for anyone to schedule an appointment for themselves, including at mobile sites in vacation communities. Both Iceland and Denmark are now offering testing for arrivals at airports. While Norway has not increased the rate of testing to the extent Denmark has, they have increased testing and access to testing over time as well. The Swedes are not yet testing at levels that catch significant numbers of asymptotic or mild cases, which is reducing the ability to contain and track the disease.

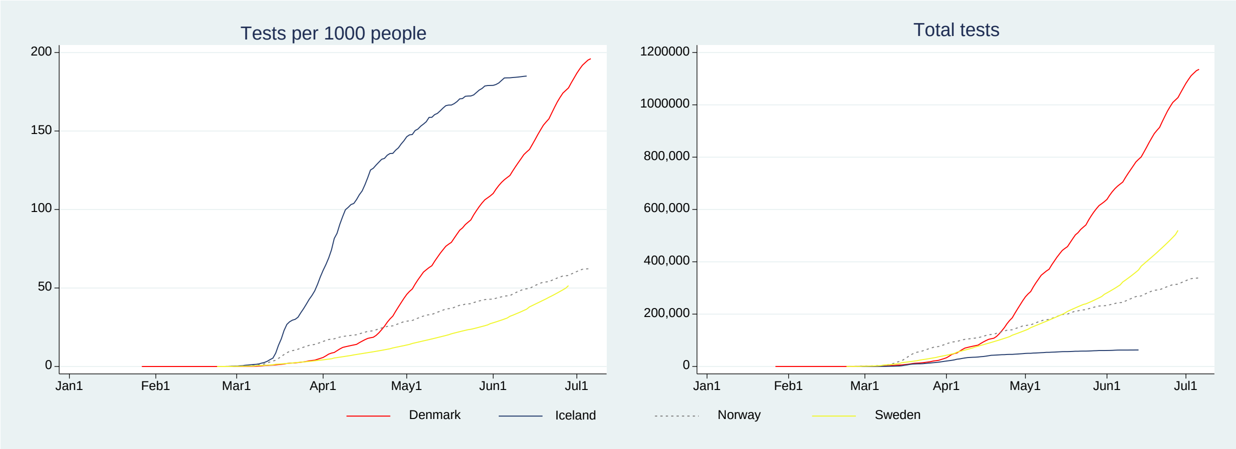

Figure 4: Per Capita and Total Testing Data for COVID-19

3.3.2. Fiscal Policy Interventions

Table 4 and Figure 5 summarize fiscal policy intervention efforts. All Scandinavian governments have implemented significant fiscal stimulus and support, totaling around 10% of the countries' 2019 GDPs. All four countries have made some form of security for wages, through which they support employers who keep workers on the payroll even when they must stay home or there is no work for them. Gaps in the programs have resulted in increased unemployment, but the increases in unemployment are significantly lower than in other countries. IMF estimates for 2020 unemployment, alongside 2019 values, are also shown in Figure 5; estimated unemployment impacts are significant despite these interventions, with Denmark and Sweden expecting to perform better than Iceland and Norway in this dimension.

Table 4: Fiscal Interventions to Counter Economic Losses from the COVID-19 Pandemic

Fiscal Intervention	Denmark	Iceland	Norway	Sweden
Discretionary spending (currency)	131.4b (DKK)	2.04 b (USD)	162.1b (NOK)	544b - 832b* (SEK)
Discretionary spending (%2019 GDP)	5.70%	10%	5.50%	10.8-16.6%*
Automatic stabilizers, expected (%2019 GDP)	5.10%	unk.	2.83%	
Wage securities** (partial)	Yes, ~75%	Yes, ~75%	Yes, ~80%	Yes, ~75%
Reduced VAT	No	No	Yes	Deferred payment

*discretionary and automatic not separated

** Arrangements differ between countries and wage structures

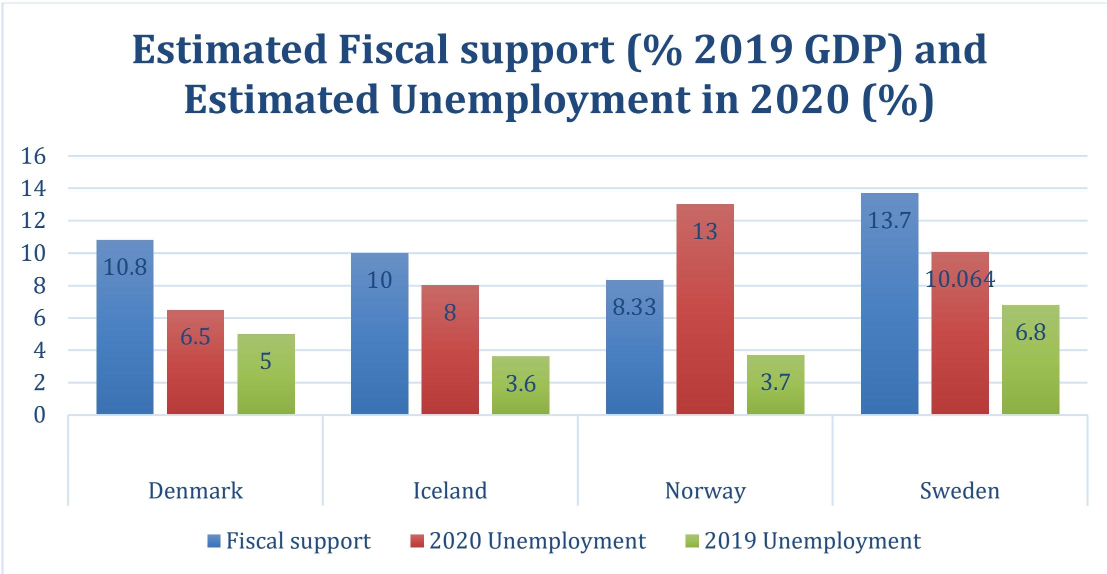

Figure 5: Estimated Fiscal Policy Support as percentage of 2019 GDP and Estimated 2020 Unemployment (IMF World Economic Outlook estimates, April 2020).

3.3.3. Monetary Policy Interventions

Monetary policy options have been limited due in large part to historically low, even negative, interest rates. Table 5 summarizes the interventions taken, which have included opening and/or expanding swap lines with the European Central Bank, the Federal Reserve, and other national European central banks and a number of special loan conditions aimed at supporting businesses.

Table 5: Monetary Policy Intervention Summary

	Denmark	Iceland	Norway	Sweden
Policy Rate	Increased 15 bps to -0.6%	Cut 175 bps to 1%	Cut 150 bps to 0%	Cut 55 bps to 0.2%
Swap lines	Yes	Yes	Yes	Yes
Special loans/ conditions	Yes	Yes	Yes	Yes
Exchange rate	Peg to Euro maintained	Flexible, 2 large (opposite) interventions	Flexible, continuous evaluation	Flexible, no interventions

3.4. Behavioral Responses

In considering Sweden as our baseline, it is important to identify what social distancing without government mandated lockdowns looks like in terms of behavior, versus a more complete lockdown.

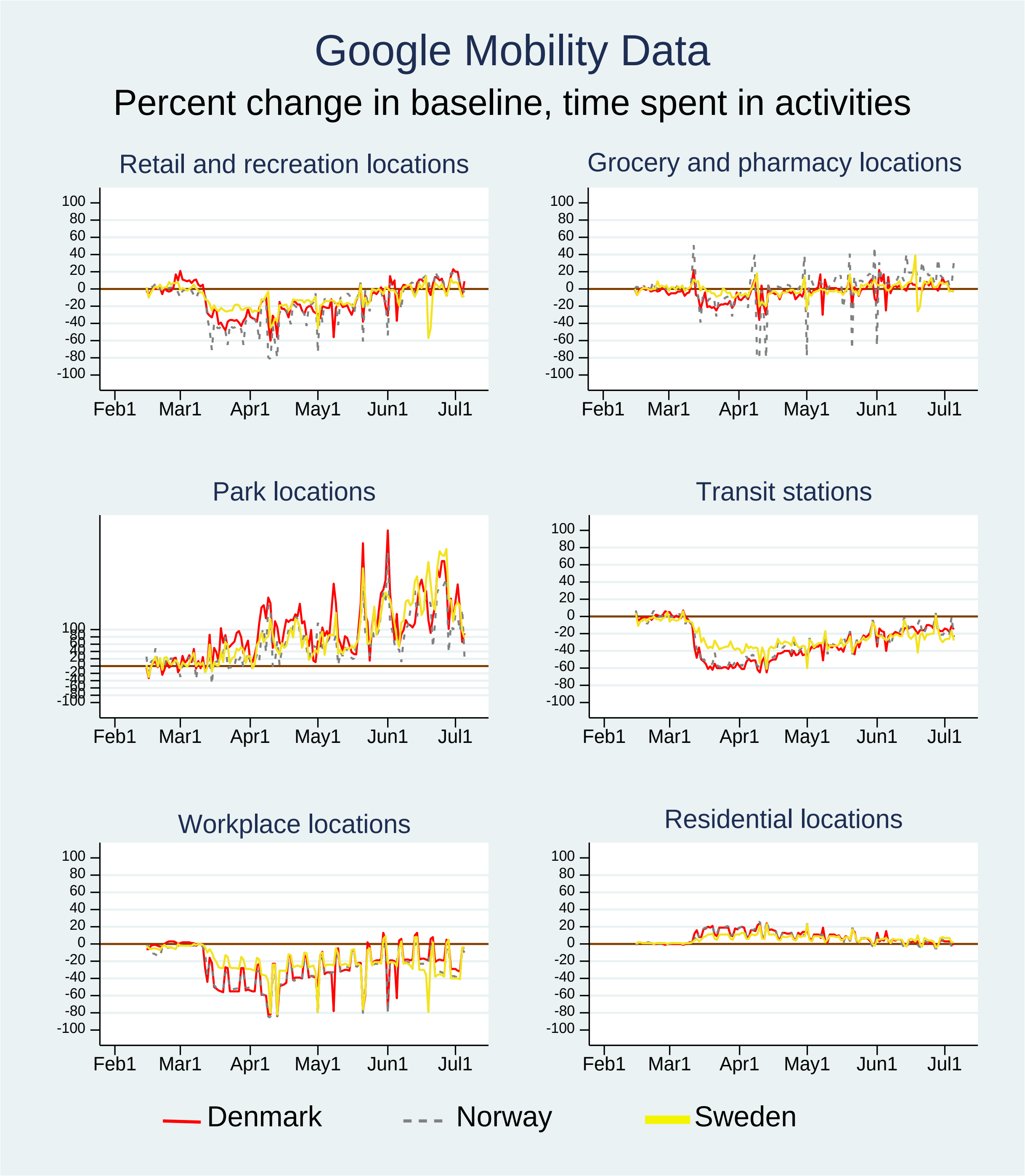

Figure 6: Google Mobility Data for Feb 15-July 5, Denmark, Norway, and Sweden.

In an effort to understand the human dynamics of the COVID-19 pandemic and response, Google has collated information from web browser use on the daily percent changes from baseline in daily visits to six types of places where visitor patterns are thought to have been impacted from COVID-19 and our responses. From Feb. 15, 2020 on, the company has used location data from web browsers to show how visits to retail and recreation, grocery and pharmacy, parks, transit stations, workplaces and residential locations have changed relative to an initial baseline. The baseline is “the median value, for the corresponding day of the week, during the 5-week period Jan 3–Feb 6, 2020” (Google LLC, 2020). The data may have selection issues relating to, among other things, seasonal changes and/or which users allow their location data to be tracked, so the results should be taken as indicative rather than definitive. There is no data available for Iceland.

One can see in Figure 6 that while the patterns for Scandinavians are very similar, the Swedes behaved differently from the Danes and Norwegians during the more stringent Danish and Norwegian restrictions, and less so before and after these periods. Swedes are changing their behaviors to reduce risks, but these changes are less intense than for Norway and Denmark; relatively, they are staying home less (*residential locations*), they are going to work more (*workplace locations*), and they have not reduced their use of public transport nearly to the same extent (*transit stations*). As the restrictions in Norway and Denmark ease, behaviors have converged again, supporting our assessment that now is a good point in time to analyze the different policies.

4. Results

4.1. Predicting New Cases

We use a random effects model for the panel composed of the 4 Scandinavian countries and a timeline from the early cases at the end of February to the beginning of July to predict new cases with two model specifications. Specification (I) relies on the bio-economic structure of a density-dependent (logistic) growth function with non-pharmaceutical interventions that slow the growth rate (spread) of the virus while specification (II) adds behavioral information on where Scandinavians have spent their time. Specification II comes at the expense of the Icelandic case, for which there is no Google Mobility data. Results for Specifications (I) and (II) are visualized in Figure 7, while parameters and diagnostics are in Appendix 3. Both specifications have high econometric fit. The visualization in Figure 7 makes clear that the addition of the mobility data is valuable, particularly in the continuing evolution of the Swedish experience. The peaks of new cases in Denmark, Norway, and Iceland are smoothed. This is likely due to the lack of spatial differentiation; a model that separated urban and rural cases, for example, should better predict the peaks.

From the regression results, we are also able to calculate a base reproduction rate (R_0) estimate of between 2.9 and 3.0. This is in line with lower- to mid- rates used or found in most models to date, which Alimohamadi et al. (2020) estimate through meta-analysis to have a mean of 3.32 (2.81-3.82).

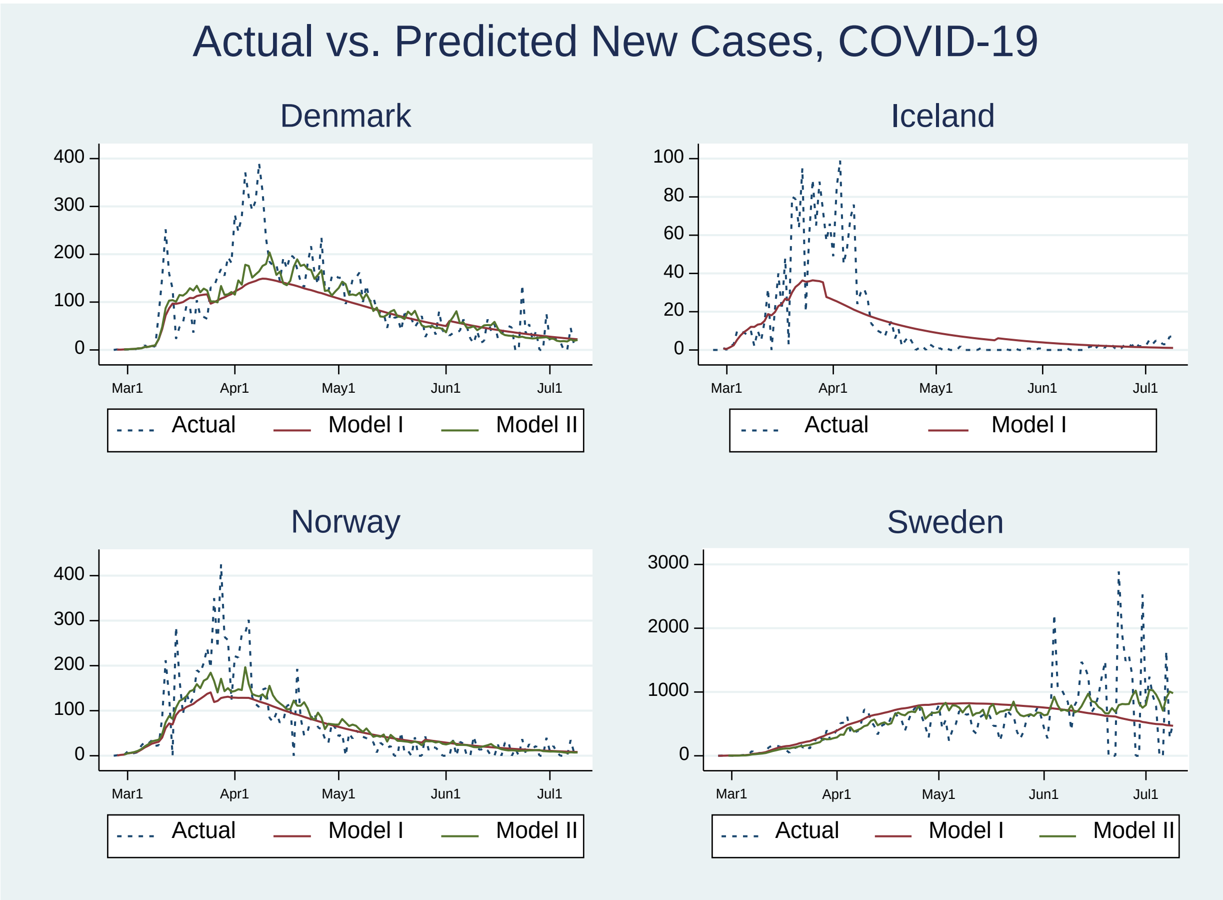

Figure 7: Actual vs. Predicted New Cases of COVID-19 in 4 Scandinavian countries over time, Feb. 26-Jul 5, 2020.

Both specifications include the closure of Middle Schools (ages 10-16, grades 6-10) lagged by two weeks for the intended effects to show. This measure is used as the most indicative of the impacts of highly collinear lockdown activities in the three countries (evidenced in Figure 1 and Table 2); by the time these students go back to school in May, the Google Mobility differences between the countries with closures and Sweden have shrunk back significantly (Figure 6). While the coefficients are negative, they are not significant. This may be due to collinearity problems with interacted timeline terms, which reflect how the virus's rate of growth has slowed much more in Denmark, Norway, and Iceland over time. It may, however, reflect the importance of behavior relative to mandate.

Density dependence is not yet a significant factor; this is expected as the infection rates remain very low compared to the overall population. Again, a more spatially granulated model, or one further into the future, might find that the virus is running out of space to spread in some communities.

4.2. Predicting Deaths from Cases

Countries may also differ in their ability to prevent cases from becoming deaths. We again construct two specifications with AR-1 processes for predicting new deaths per 1000 people using our panel data[4], with similar reasoning to the above. Specification (Id) includes Iceland and uses only lagged cases per 1000 people, tests per 1000 people, school closing and hospital capacities (fixed effect) to predict new deaths, while specification (IId) excludes Iceland but includes behavioral information from Google Mobility data. Again, both specifications have good fits. The regression results are in Appendix 4.

In all specifications, the lagged total case rates are unsurprisingly significant factors. Furthermore, higher testing rates (lagged) indicate significantly lower death rates. This suggests that people are able and willing to act on the information contained in testing in ways that reduce deaths. Indeed, Iceland's early and aggressive testing and Denmark's dramatic increases in testing (recall Figure 4) are quite different policies from Sweden's poor testing performance. Testing aggressively, a parallel to monitoring and early detection of environmental and health problems more broadly, should be recognized as a vital component of the precautionary principle.

Additionally, in both cases, lagged middle school closures do have significant negative coefficients. This suggests that closing schools and/or correlated mandates to stay home have helped keep increasing cases from translating to increasing deaths, even if they did not significantly contribute to reducing cases. There may be many reasons for this, which this analysis cannot fully address, but may include significantly reduced activity outside the home by all family members if children are at home. This is aided by the supportive Scandinavian approach to work-life balance, which for example even in non-coronavirus times, facilitates parents' ability to stay

[4] AR processes are anticipated in the time series due to the progressive nature of the virus, and AR-1 is confirmed by a Wooldridge test for serial correlation using xtserial following Wooldridge (2002) and Drukker (2003).

home for the first days of a child's illness, and provides other short and long term leaves for illness of oneself and one's family members (Øresunddirekt, 2020a; Øresunddirekt, 2020b; NAV, 2020, Nordic Co-operation, 2020).

As shown in the previous section, Sweden has exceeded its hospital capacities, while the other countries have not come close. Higher hospital capacities, which in this case are ordered fixed effects (recall Table 3), do coincide with lower rates of conversion from cases to deaths in both specifications; this undoubtedly reflects not only relative hospital capacities but other fixed effects between the countries.

Unlike the estimation of new cases, behavioral information adds little in terms of significant results. This is not surprising given the lack of knowledge about how to treat the virus, so that it must generally run its natural course once contracted.

4.3. Avoided Cases and Deaths in Denmark, Iceland and Norway.

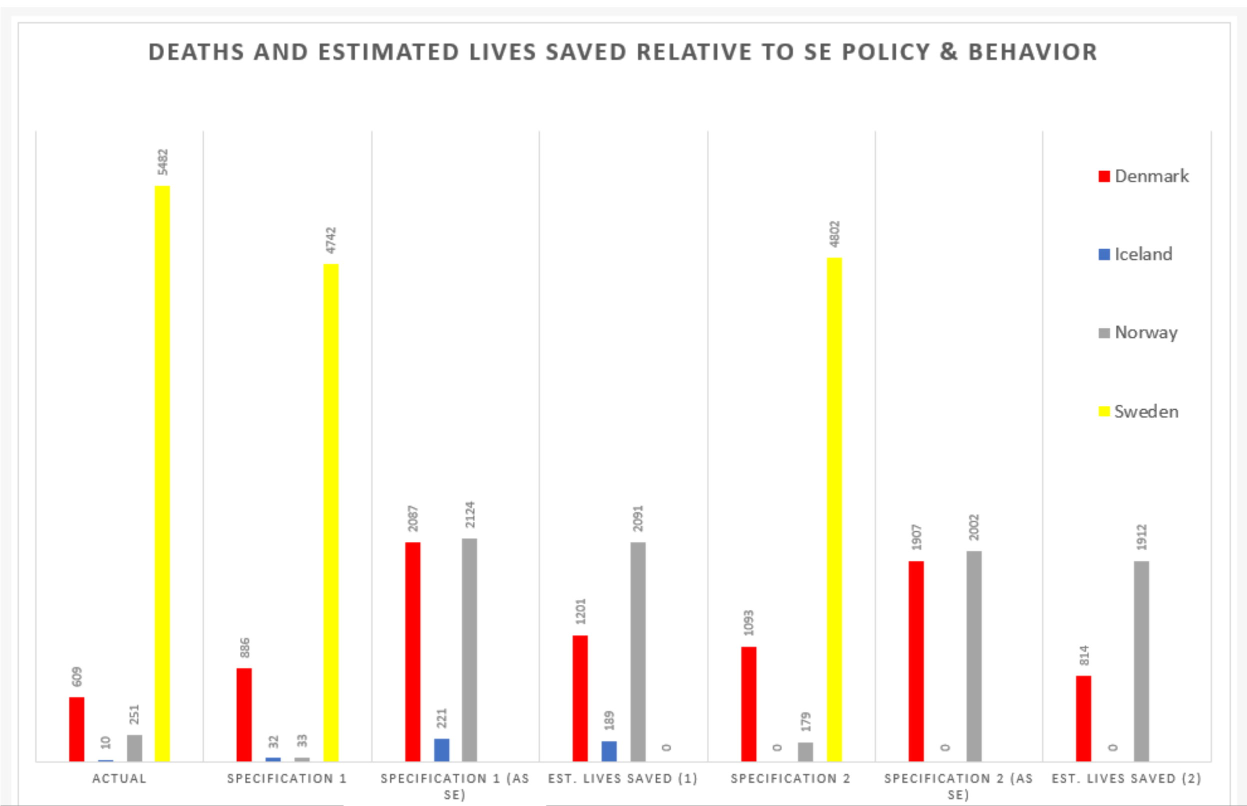

Figure 8: Actual and estimated deaths and estimated lives saved in DK, IS, and NO relative to SE behavior

Figure 9 shows the actual and estimated total deaths in the four countries for the two model specifications, alongside estimated deaths if Denmark, Iceland and Norway had policies and behaviors that replicated Sweden's (data in tabular form in Appendix 5). Estimated lives saved for DK, IS, and NO combined under Specification (I) are 3,481, while for Specification (II), with DK and NO only, the total is 2,726. The models somewhat overestimate deaths in Denmark and Iceland but underestimate them in Norway and Sweden.

4.4. Estimated Damages

4.4.1. Estimated Value of Statistical Lives Saved (VSL)

We have two sets of estimates of value of statistical lives that parameterize the expected gains from social distancing and lockdown. Viscusi (2017) provides the income adjusted VSL figures in Table 6.

Table 6: US-based and Own-Country VSL figures

Country	VSL (Viscusi 2017, 2015 USD)	VSL (Natl. Figs. in 2015 USD) (1)
Denmark	10.073 m	5.097 m
Iceland	8.600 m	No national estimate
Norway	16.127 m	4.75 m
Sweden	9.965 m	3.99 m

(1) National figures converted to USD using 2019 exchange rate (IRS) average (and deflated to 2015 with GDP deflator from measuringworth.com:
DK: 34 m DKK (2019), finance ministry (fm.dk)
IS: no estimate
NO: 34.940 NOK (2019) TØI rapport 1704/2019
SE: 40.5 M SEK (2019), Trafikverket

4.4.2. Range of Estimated Losses

We calculate a range of estimated losses in billions of 2019 USD. For the low end, we assume that government expenditures are covered with future growth and do not include them. We also use the lower value estimates for VSL and the lowest estimates for GDP losses. The mean estimates also ignore government expenditures, but they include the higher VSL figures and the mean estimates for GDP losses. For the high end, we include government expenditures as well as use the higher VSL figures and the worst-case GDP loss scenarios. Figure 10 shows that Iceland faces the lowest expected total losses. At the mean, this translates to $5,781 per capita (Table 7). This is higher than the Danish and Norwegian per capita losses, which are $4,124 and

$4,541 respectively. Sweden outpaces all three countries with a mean per capita loss estimate of $8,300. At the top end, the per capita figures are $12,524 (NO), $13,559 (DK), $15,279 (IS), and $17,004 (SE). Supporting calculations for estimates of lives saved are in Appendix 5.

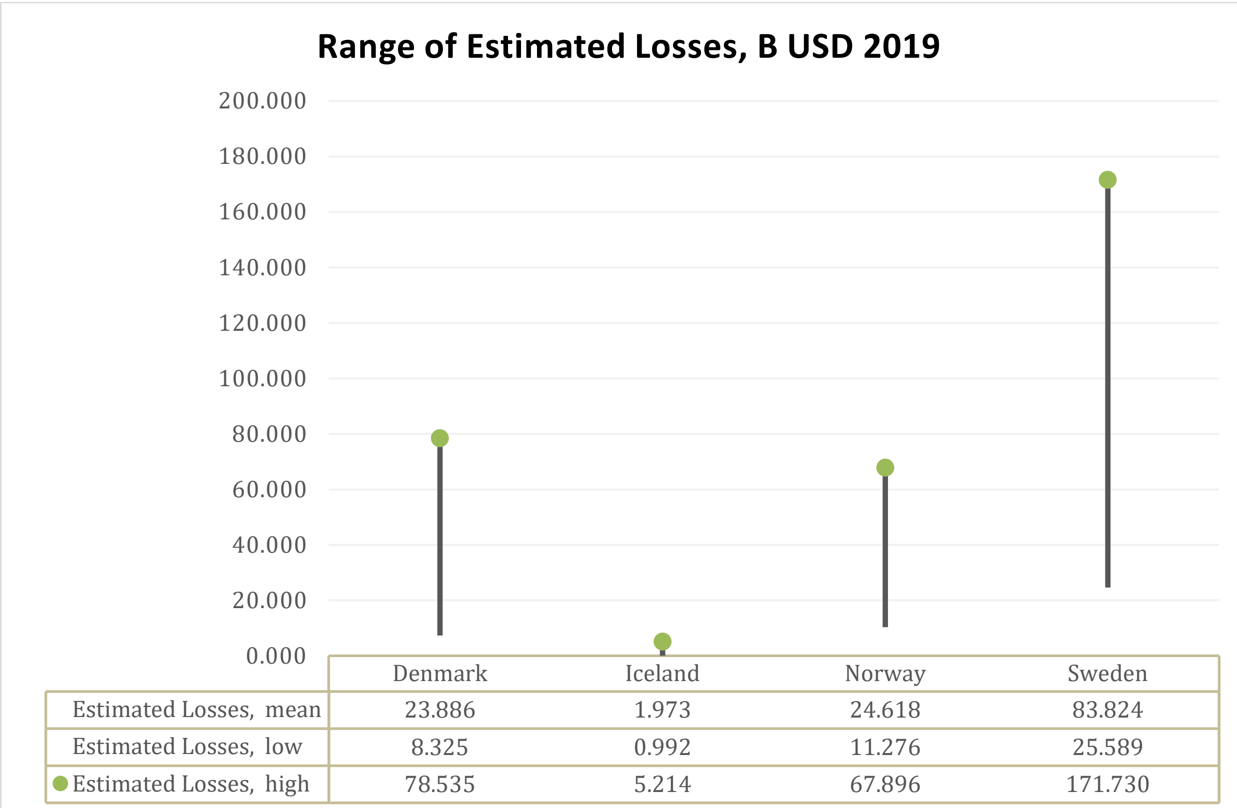

Figure 9: Estimated losses (B USD) to Scandinavian countries through June 2020.

Table 7: Per capita estimated losses (USD) to Scandinavian countries through June 2020

	Denmark	Iceland	Norway	Sweden
Mean Per Capita Losses	4,124	5,781	4,541	8,300
Low Per Capita Losses	1,437	2,906	2,079	2,533
High Per Capita Losses	13,559	15,279	12,524	17,004

Finally, we estimate the VSL attributable to the precautionary approach that drove lockdown mandates. We find that the Danish savings relative to a Swedish approach range from 4.149 billion USD to 12.098 billion USD, Icelandic savings relative to a Swedish approach are estimated at 1.625 billion USD, and Norwegian savings range from 9.082 billion USD to 33.722 billion USD. The per capita values are shown in Table 8, alongside the breakdowns of these ranges.

Estimated per capita savings from the precautionary approach in lives saved are of approximately the same magnitude as or larger than the damages incurred in these countries. The benefits to date of stricter restrictions have been substantial.

Table 8: VSL of Lives Saved by Precautionary Approach

VSL Values for Lives Saved by Precautionary Approaches relative to SE, through June 2020			
	DK	IS	NO
Precautionary Approach Value in Avoided Deaths (I), US, B USD	12.097673	1.6254	33.72156
Precautionary Approach Value in Avoided Deaths (II), US B USD	8.199422		30.83482
Precautionary Approach Value in Avoided Deaths (I), Own, B USD	6.121497		9.93225
Precautionary Approach Value in Avoided Deaths (II), Own, B USD	4.148958		9.082
Per capita low estimates (USD)	716		1675
Per capita high estimates (USD)	2089	4763	6220

5. Discussion

5.1. Issues of Incidence and Insurance

In considering the net costs and damages of the pandemic, we have not considered incidence in any detail. Government support in all four countries has postponed and distributed costs of unemployment, and long run impacts are difficult to assess at this time.

For businesses, the burden of incidence remains unclear, and depends on how insurance claims and legal controversies are resolved. As insurance is a key tool for risk management, it is useful to understand how the pandemic is affecting the industry in Scandinavia. Overall, the influence in the insurance sector is diverse and depends on the carrier's exposure in various insurance lines. The lines of insurance that are suffering the most significant losses in Scandinavia so far seem to be those that are negatively influenced by the forced stop in activities, e.g., travel insurance, event cancellation insurance, etc. On the other hand, some have been positively influenced by a stop. Most clearly this is being seen in private property claims and motor claims. Burglaries have been declining in private homes, and other claims are also expected to decrease as well, as homes have been watched over 24/7. Motor claims have significantly decreased as a consequence of people traveling less.

As the crisis was not perceived by most individual decision-makers to be a likely threat before it occurred, many insurance policies have failed to include appropriate coverage for the actual impacts. Where it has been included in the apparent scope of coverage, several currently contested legal factors affect eligibility for insurance compensation. For example, the government's instructions are seen to affect the eligibility for compensation. Lack of precision in the lockdown strategy can cause clients to fail to qualify for compensation, which has been an effect of the more open instructions in Sweden.

The rapid change in the risk landscape has made it difficult to foresee the short- and long-term economic effects in the insurance market. Future data will provide a better understanding of how different lockdown strategies have affected the insurance market and how the market will mitigate future pandemic crises in the world and/or distribute the costs across those affected.

The virus itself has to date overwhelmingly affected elderly individuals in the Scandinavian countries, particularly elderly individuals in elder care homes. In addition to the interest in weighing the meaning of this uneven distribution, this suggests that an age-structured SEIR model may be appropriate for future work. Sweden, in one of its few strict restrictions finally banned most visits to elder care facilities, has admitted that it should have done more, earlier, to reduce contact between elderly populations and others (The Local, 2020) and would likely have reduced deaths in so doing.

5.2. Substitution and Income effects

Much has been made of the improvements in air quality from reduced travel during the pandemic, with e.g. claims of up to 30% reductions in pollution in some locations with the strictest lockdowns (Muhammad et al, 2020). To the extent these gains are real, they are not expected to last, unless the break in activity produces other substitutions. A cursory examination of the data for major Scandinavian cities (Appendix 6) suggests possibilities worthy of further investigation. In particular, while nitrous oxides, the main regional pollutants from transportation vehicles, are lower during the main 'lockdown' months of March and April 2020 vs. 2019, for Denmark, Norway and Sweden, they are also lower for other months versus 2019 as well. Scandinavian countries, particularly Norway, have already invested significantly in urban air quality as they have become some of the richest countries in the world. Oil prices have declined, reducing Norwegian wealth and increasing the opportunity costs of transitioning to more fuel-efficient transport. If, as can be expected, these effects and the broader economic losses of the pandemic divert efforts from both private and public long-term plans to improve environmental quality, this will add to the overall losses generated by the pandemic.

6. Conclusions

For Denmark, Iceland, and Norway, precautionary principle approaches that include successful testing and tracing strategies have paid off to date. They have saved lives estimated to be worth up to 47.4 billion USD, with no measurable tradeoff in economic consequences compared to Sweden. We use a bio-economic model of growth in the disease and augment it with behavioral information from Google Mobility data. The model predicts cases and deaths from COVID-19 well and confirms R_0's for Scandinavian countries of ~3, as found by others. Both government mandates and individual changes in behaviors reduce the reproduction rate over time; countries with more strict mandates have seen fewer deaths than those without.

The comparison of the Scandinavian countries' early experience with the novel coronavirus in the first half of 2020 provides an opportunity to evaluate precautionary approaches to BAU risk management. The results emphasize that the idea of a clean tradeoff between economic and health outcomes is a false dichotomy. The problem is rather a joint cost and damage minimizing exercise, with inseparable interactions.

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Appendix 1: Summary of GDP Growth estimates

Real GDP 2020 Annual Growth Rate Estimates since Feb 15.

Country	Mean	Std. Dev.	Min	Max	# Estimates	Sources
Denmark	-5.1	2.2	-10	-1.5	20	Danish Economic Council, Danish National Bank, DanskeBank, Nordea, Focus Economics, SEB, IMF, EC, OECD, Reuters Poll
Iceland	-7.8	2.4	-11.2	-4.1	8	Central Bank of Iceland, Landsbankinn, Focus Economics, IMF, EC, OECD, Statistics Iceland
Norway	-5.1	1.7	-7.5	-2.5	10	DanskeBank, Nordea, Focus Economics, SEB, IMF, EC, OECD, Reuters Poll
Sweden	-5.5	2.4	-12	-0.7	18	National Institute for Economic Research (SE), DanskeBank, Nordea, Focus Economics, SEB, IMF, EC, OECD, Reuters Poll, Statista

Appendix 2: Supporting data from hospitalizations

Norwegian data does not identify daily totals of patients. Instead, Figure A2.1 shows the cumulative total IC hospitalizations for COVID-19 alongside the new admittances each day. The numbers are in line with Figure 2.

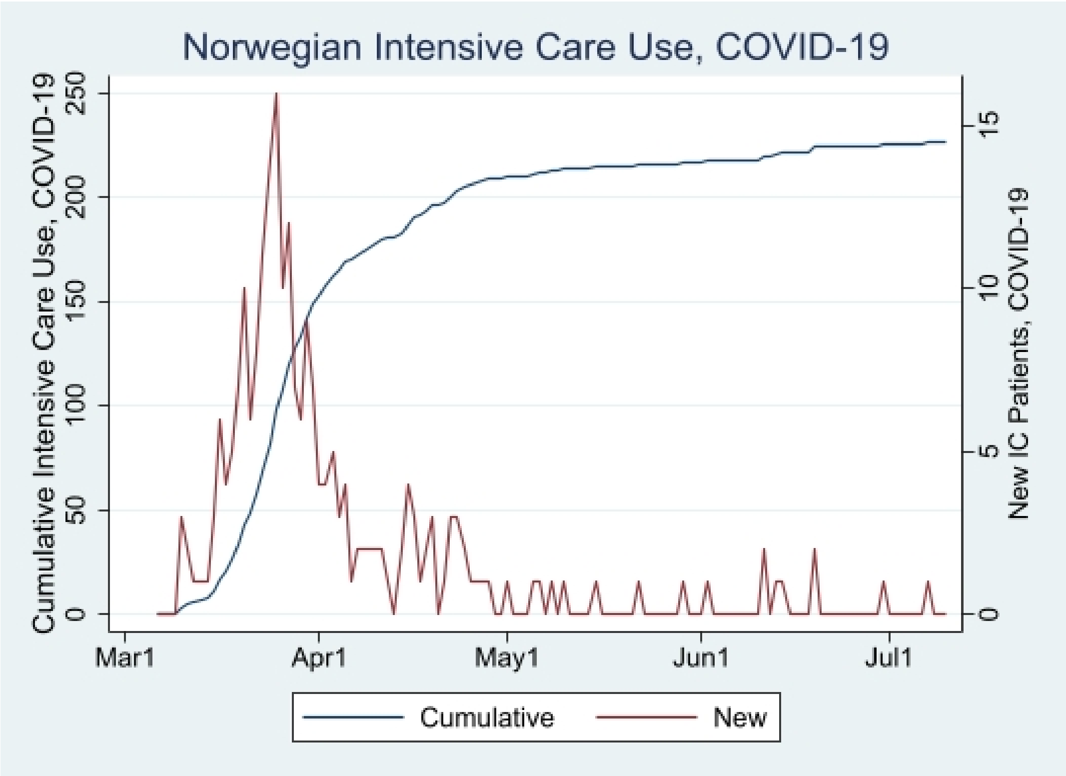

Figure A2.1: Norwegian intensive care use, COVID-19.

Swedish data identifies procedures but not days on ventilator. Ventilator procedures do appear a relatively stable share of IC days. New Swedish IC use has not increased as cases and deaths have grown in late June and July.

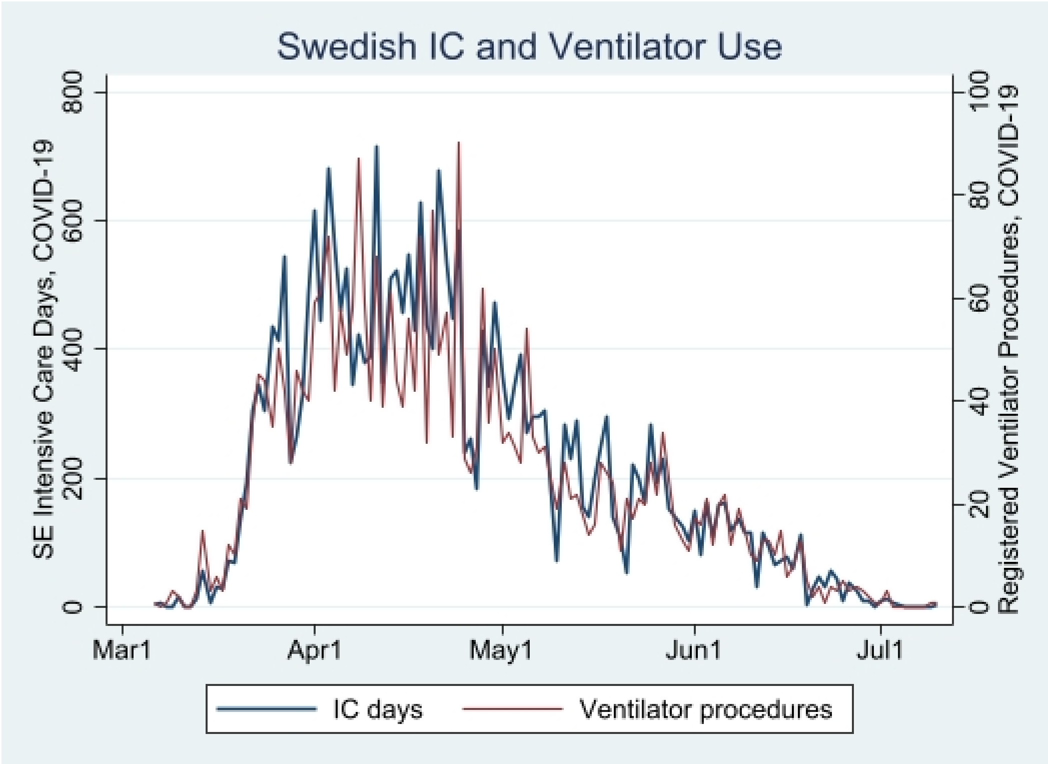

Figure A2.2: Swedish intensive care and ventilator use.

Appendix 3: Regression Results for Predicting New Cases

Dependent variable: New cases (ln)	Panel regression	
time unit: daily	RE model, Robust std. err.	
panel: Denmark, Iceland‡, Norway, Sweden	P-values in parentheses	

Variable	Specification I	Specification II
Total Cases (ln)	0.817	0.879
	(0.000)	(0.000)
Middle schools (age 10-16) closed,	-0.222	-0.352
14 day lag	(0.458)	(0.209)
Denmark*Days from first case	-0.028	-0.041
	(0.000)	(0.000)
Norway*Days from first case	-0.034	-0.046
	(0.000)	(0.000)
Iceland*Days from first case	-0.034	
	(0.002)	
Sweden*Days from first case	-0.006	-0.021
	(0.348)	(0.000)
		-
Density measure (ln)	219.84	24.592
	(0.295)	(0.742)
Percent change in transit station frequency,		-0.005
14 day lag		(0.573)
Percent change in residential frequency,		-0.021
14 day lag		(0.215)
Percent change in retail frequency,		-0.002
14 day lag		(0.000)
Percent change in grocery frequency,		0.004
14 day lag		(0.002)
Percent change in parks frequency,		0.002
14 day lag		(0.000)
Percent change in work frequency,		-0.006
14 day lag		(0.844)
Constant	-0.409	-0.469
	(0.000)	(0.000)
R-sq (within)	0.773	0.827
R-sq (between)	0.998	0.999
R-sq (overall)	0.874	0.884
N.Obs.	456	358
N.Groups	4	3
sigma_u	0	0
sigma_e	0.0669	0.545
rho	0	0
Estimated R_0	**2.927**	**3.034**

‡ Google Mobility data is not available for Iceland

Appendix 4: Regression Results for Predicting Mortality Rates

Dependent variable: new deaths per 1000 ppl	Panel Data Regression	
time unit: daily	RE model with AR(1)	
panel: Denmark, Iceland‡, Norway, Sweden	P-values in parentheses	
	Specification	
Variable	Id	IId
Total cases per 1000 ppl, 14 day lag (ln)	0.0016	0.0017
	(0.000)	(0.000)
Total tests, 14 day lag*	-0.0018	-0.0018
	(0.000)	(0.000)
Middle schools closed (ages 10-16), 14 day lag	-0.0006	
	(0.084)	
Hospital beds per 1000 ppl**	-0.0013	-0.0014
	(0.004)	(0.005)
Percent change in transit station frequency, 14 day lag		2.54*10^-5
		(0.388)
Percent change in residential frequency, 14 day lag		9.12*10^-5
		(0.225)
Percent change in retail frequency, 14 day lag		-2.53E-05
		(0.161)
Percent change in grocery frequency, 14 day lag		1.71*10^-5
		(0.190)
Percent change in parks frequency, 14 day lag		1.82*10^-6
		(0.633)
Percent change in work frequency, 14 day lag		2.66*10^-5
		(0.219)
Constant	0.011	0.011
	(0.000)	(0.000)
R-sq (within)	0.123	0.09
R-sq (between)	0.933	0.9262
R-sq (overall)	0.402	0.378
	78.26	53.18
Wald chi^2	(0.000)	(0.000)
N.Obs.	470	364
N.Groups	4	3
rho (AR)	0.483	0.530
sigma_u	0.0002	3.142
sigma_e	0.002	20.844
rho	0.016	0.022

*test data for Sweden is smoothed over weekly observations

** fixed by country. See Table 3.

‡ Google Mobility data is not available for Iceland

Appendix 5: Estimated Deaths and Lives Saved

Deaths	Denmark	Iceland	Norway	Sweden
Actual	609	10	251	5482
Specification 1	886	32	33	4742
Specification 2	1093	n.a.	179	4802
Specification 1 (as SE)	2087	221	2124	
Est. Lives Saved (1)	1201	189	2091	
Specification 2 (as SE)	1907	n.a.	2002	
Est. Lives Saved (2)	814	n.a.	1912	

Appendix 6: Air Quality, Scandinavian Cities