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Modelling economic policy issues

Cross-country effects and policy responses to COVID-19 in 2020: The Nordic countries

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ABSTRACT

We provide a three-step analysis of the effects and responses to COVID-19 in Nordic countries (Denmark, Finland, Norway and Sweden), large Western European countries (France, Germany, Italy, Spain and United Kingdom) and OECD Europe. First, we compare public health trends over 2020 in terms of per capita COVID-19 cases, fatalities, testing and the stringency of social distancing (SD) measures. Second, in a 'like-with-like' policy response model between Nordic countries, we test for the effects of air border closures on the growth in per capita COVID-19 cases while accounting for differences in stringency of social distancing and other measures. Third, using data from OECD European countries, we regress percentage change in GDP (2020–2019) on cumulative per capita national COVID-19 fatalities. We find that: (1) Sweden is an outlier, relative to its Nordic neighbours, in its COVID-19 public health outcomes; (2) Sweden would have had reduced cases and fatalities if it had adopted the air border closures implemented by its Nordic neighbours in the first half of 2020; and, (3) for OECD Europe, there is a statistically significant and negative association between per capita COVID-19 fatalities and economic performance.

1. Introduction

The SARS-CoV-2 virus (Wu et al., 2020) that causes COVID-19 was first observed in China in December 2019 and declared a global pandemic on 11 March 2020 (WHO, 2020a). As early as February 2020, some countries implemented a series of public health measures to stop the spread of COVID-19. Measures differed by country but included international travel restrictions from China, and later from other infected countries, as well as quarantine of travellers from COVID-19 'hot spots', and the testing for the virus in new arrivals that exhibited fever or flu-like symptoms.

The European Union (EU) first imposed internal border restrictions on persons travelling from Italy on 17 February 2020. Several EU member countries also imposed their own border controls. On 17 March 2020 the EU imposed external border closures for all non-essential travel. By April 2020, most high-income countries had imposed some form of border restrictions while some countries (such as Australia and New Zealand) further required that all incoming arrivals be placed in supervised quarantine for 14 days and to test negative for virus shedding before leaving quarantine.

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Unlike its Nordic neighbours, Sweden maintained an open border in the first half of 2020 within the EU and beyond and imposed no quarantine requirements for arrivals. From 31 October 2020, Sweden banned non-essential travel, except for Swedish citizens, from countries outside of the EU (Krisinformation, 2020a). Sweden's open border policy arose because, according to Anders Tegnell in April 2020, and who is the Chief Epidemiologist at the Swedish Public Health Agency, "Closing borders, in my opinion, is ridiculous, because COVID-19 is in every European country now. We have more concerns about movements inside Sweden" (Paterlini, 2020).

In addition to an open border, Sweden sought to minimise its government-mandated social distancing (SD) measures to suppress COVID-19 infections (Krisinformation, 2020b) and placed a greater reliance on voluntary behaviours of Swedish residents to comply with national health advisories (Eaton, 2020; Habib, 2020; Ludvigsson, 2020). At least in the early months of the pandemic, voluntary SD reduced the frequency and proximity of social interactions outside of the home by Swedes (Savage, 2020). The justification for the reliance on voluntary SD and advisories in Sweden, rather than enforcement of government mandated SD rules, was two-fold. First, it was claimed that government-mandated and stringent SD would not be successful over the long term, should the pandemic continue for years, because its population would not accept or comply with extended periods of mandated SD (Paterlini, 2020). Second, voluntary SD and open borders would impose a lower cost on the economy than more stringent, government-mandated SD (Coy and Daly, 2020).

Our contribution includes: (1) a comparison of trends over 2020 in public health performance, based on public data, of Nordic countries and also large Western European countries in terms of; confirmed cases, fatalities, testing, and the stringency of SD measures; (2) a policy response model of the effects of border closures in Nordic countries, imposed in the first half of 2020, on the growth in per capita COVID-19 cases; (3) an empirical analysis of the association between COVID-19 fatalities in OECD European countries in 2020 and the percentage change in Gross Domestic Product (GDP) from 2019 to 2020.

2. Responses of Nordic countries to COVID-19

As the 'first wave' of COVID-19 hit northern Europe in March 2020, Norway introduced stringent SD measures from March 12, 2020 that included working from home, controls on both domestic and abroad travel, and limits on the number of people for gatherings. Finland and Denmark introduced similar SD measures to Norway, but Denmark also imposed a maximum of 10 people per gathering. Initially, Sweden imposed less stringent SD measures than its Nordic neighbours but did ban gatherings of more than 500 people and provided advisories to avoid unnecessary travel. In mid-April, Denmark began to relax its SD measures, Norway followed from early May and Finland followed from the end of May 2020.

As the 'second wave' of COVID-19 infections progressed at the end of the northern hemisphere summer, Denmark, Norway and Finland gradually reimposed SD measures. Face mask recommendations started in August in Denmark, and in Norway and Finland in September. In late October, Norwegians were not allowed to have more than 5 guests in private homes and a maximum of 50 people were allowed at private gatherings on public premises, reduced to 20 on November 5, 2020. In November, Denmark reduced the maximum number of people it allowed to gather from 50 to 10 and also mandated face covers in all public places.

In response to on-going increases in confirmed cases, on November 24 Sweden imposed more stringent SD such that only eight people were allowed to gather together, and gyms and libraries were closed. By late December 2020, Sweden had the most stringent SD rules of all Nordic countries; these measures included a maximum of four people allowed to gather at restaurant, mandatory mask wearing on public transport and the closure of high schools. Denmark, in response to its second wave of infections, implemented a national lockdown from 25 December 2020.

3. Results

3.1. Data and methods

Publicly available national and global data sources from 1 January to 31 December 2020 were used to provide time trends of cases, fatalities, testing, quarterly GDP growth and stringency of government-mandated SD measures (Hale et al., 2020) for the Nordic countries; Denmark, Finland, Norway and Sweden, and, for comparison purposes, the large Western European countries (France, Germany, Italy, Spain and United Kingdom). All data sources and summary comparative statistics are available on request from the authors. With the exception of Iceland that is an island with a much smaller population than other Nordic countries, the Nordic counties are considered to be peers in relation to COVID-19 and all have a similar age structure, life expectancy, welfare support, geography, per capita income, and quality of health care.

Our analyses are in three parts. First, time-trends are provided on key public health variables for the Nordic countries, and also the large Western European countries for comparative purposes, from 1 January to 31 December 2020. These time trend comparisons illustrate differences across countries in relation to per capita COVID-19 per capita cases, fatalities, testing, and also SD as measured by a publicly available Stringency Index from University of Oxford. Second, we estimate a policy response model to quantify the effects of border closures in the Nordic countries accounting for differences over time and the stringency of their SD measures. Third, we provide a comparison between the Nordic countries and also among the large Western European nations, in terms of the changes in quarterly fatalities and quarterly GDP in 2020. Further, we regress the percentage change in annual GDP from 2019 to 2020 for OECD European countries against per capita fatalities due to COVID-19.

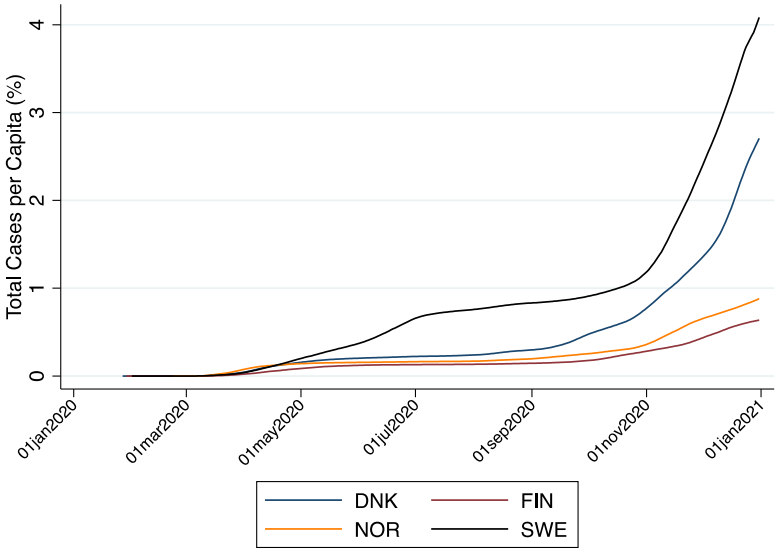

Fig. 1a. Total cases per capita (%): Denmark, Finland, Norway and Sweden (seven-day average).

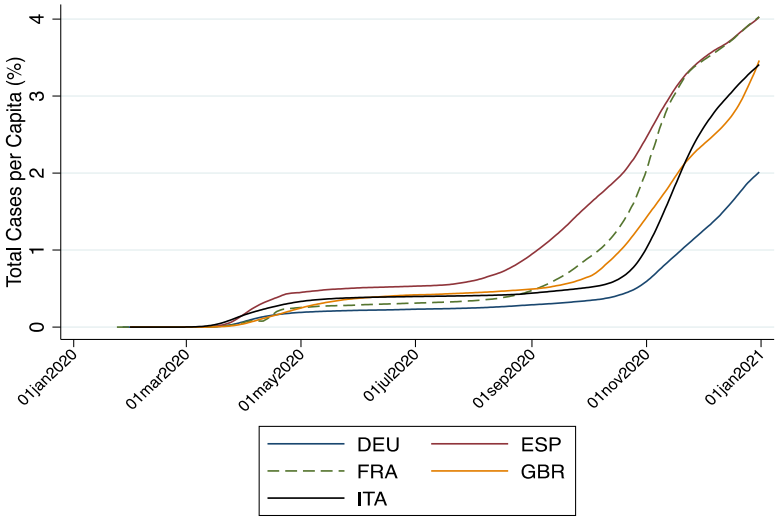

Fig. 1b. Total cases per capita (%): France, Germany, Italy, Spain, and United Kingdom (seven-day average).

3.2. Cross-country Trend Comparisons: Nordic and large Western European countries

Figs. 1a and 1b, respectively, provide total cases of COVID-19 in our four Nordic countries and the large Western European countries (France, Germany, Italy, Spain and United Kingdom) as percentage of their respective national populations. In terms of per capita total cases, at the end of 2020, Sweden had the highest confirmed case rate of all Nordic countries at some 4% of the population, followed by Denmark at 3%, and 2% or less for Finland and Norway. Only Sweden had cases per capita comparable to the rates of large Western European countries such as France, Spain, Italy and the United Kingdom, but Germany's per capita case rate was half that of Sweden.

Figs. 2a and 2b, respectively, provide total fatalities for the Nordic countries and the large Western European countries available from 'Our World in Data' noting that the recorded data varies slightly depending on the source. All Nordic countries and large western European countries experienced a slowing of per capita fatalities over the northern summer but then suffered a sharp rise in fatalities from November 2020 with a 'second wave' of COVID-19 infections. Sweden's total fatalities per capita have been much higher than its Nordic peers since April 2020 and at the end of 2020 was 0.08% of the population, approximately four times higher than the next highest per capita fatality rate in Denmark. Sweden's fatalities per capita, however, were comparable to the COVID-19 fatality rate of the large Western European countries, with the exception of Germany, which had a much lower fatality rate of 0.04%.

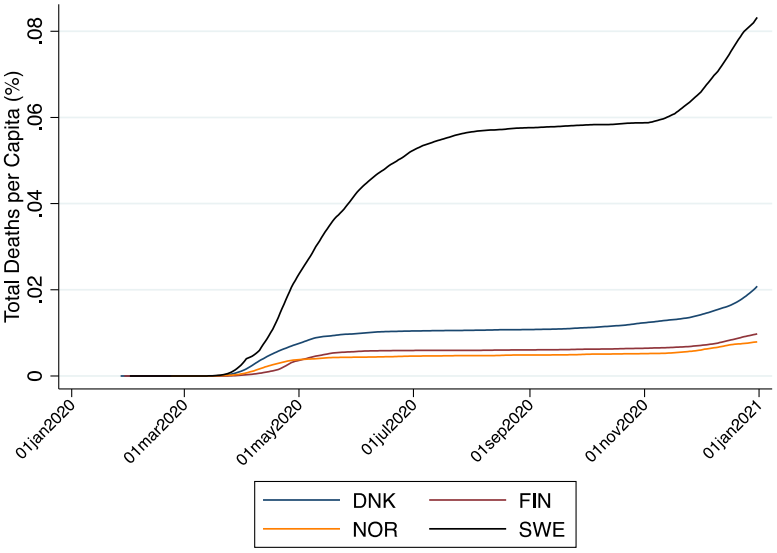

Fig. 2a. Total fatalities per capita (%): Denmark, Finland, Norway and Sweden (seven-day average).

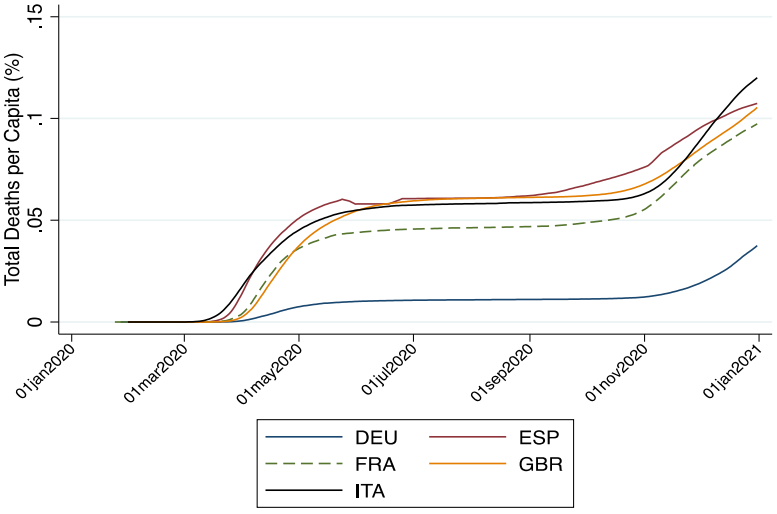

Fig. 2b. Total fatalities per capita (%): France, Germany, Italy, Spain, and United Kingdom (seven-day average).

A key public health response to the pandemic is testing and contact tracing of confirmed cases. Figs. 3a and 3b provide, respectively, cumulative tests per confirmed cases for Nordic countries and the large Western European countries. Of all countries, Nordic and large western European countries, Sweden has had a much lower testing rate at about one hundredth of the rate of any of its Nordic neighbours and about one tenth of large Western European countries. Since July 2020, the testing rate increased substantially in Sweden, but it still remains a small fraction of any country in our study.

Figs. 4a and 4b provide an index (0 to 100, with 100 being the most stringent) of the stringency of government-mandated SD measures using an aggregate of the sub-indices C1–C8, E1 and H1–H3 from the University of Oxford Coronavirus Government Response Tracker (for details see https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker). Sweden, initially, had the lowest stringency level of all Nordic countries over the March–early April period of between 40 and 50 but its stringency index reached a little over 60 in May 2020 when its index exceeded that of Finland and Norway.

The stringency index of Nordic countries changed little over the northern hemisphere summer but increased in a series of measures beginning in October 2020. By the end of 2020, Sweden's stringency index was around 70, and at a level higher than any other Nordic country. The large western European countries (Fig. 4b) followed a similar temporal pattern to Nordic countries but differed in terms of the levels and timing of their SD measures. For example, Italy had

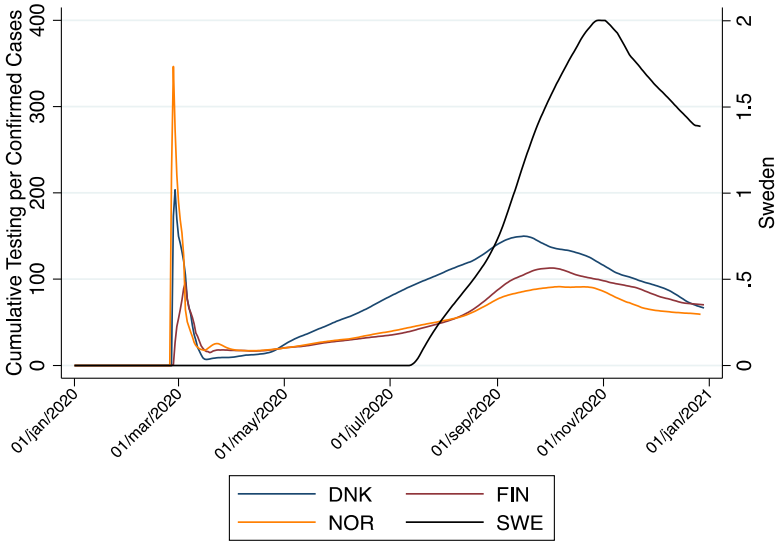

Fig. 3a. Cumulative testing per confirmed cases: Denmark, Finland, Norway and Sweden (seven-day average).

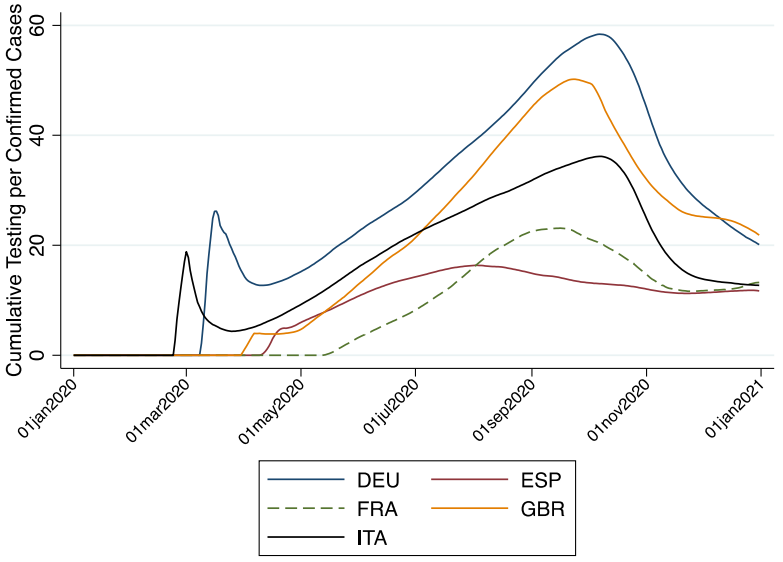

Fig. 3b. Cumulative testing per confirmed cases: France, Germany, Italy, Spain, and United Kingdom (seven-day average).

the highest stringency measure of any of the selected countries in the first wave as its SD measures were implemented sooner because it was the first European country to experience a COVID-19 epidemic.

3.3. Effects of border closures in Nordic countries

Nordic countries have imposed a variety of health policy restrictions to control and curb the pandemic (Fig. 4a) that, in some countries, have included the closure of air borders to international travellers. Here, we model and measure the significance of full international air border closure on total COVID-19 cases in the Nordic countries.

Before detailing our analyses, we observe that all Nordic countries, at least for a period of time, enforced a full air border closure early in the pandemic, except Sweden. Our policy response model uses binary variables to control for country effects and the decision on international air border closure data available from 'Our World in Data' (https://github.com/owid/COVID-19-19-data/blob/master/public/data/owid-COVID-19-data.xlsx) and the 'University of Oxford Coronavirus Government Response Tracker' (https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker). Our dependent variable is defined as the growth in total per capita COVID-19 cases that we calculate from 'Our World in Data'. We employ a seven-day average to avoid daily reporting fluctuations that can arise from different daily

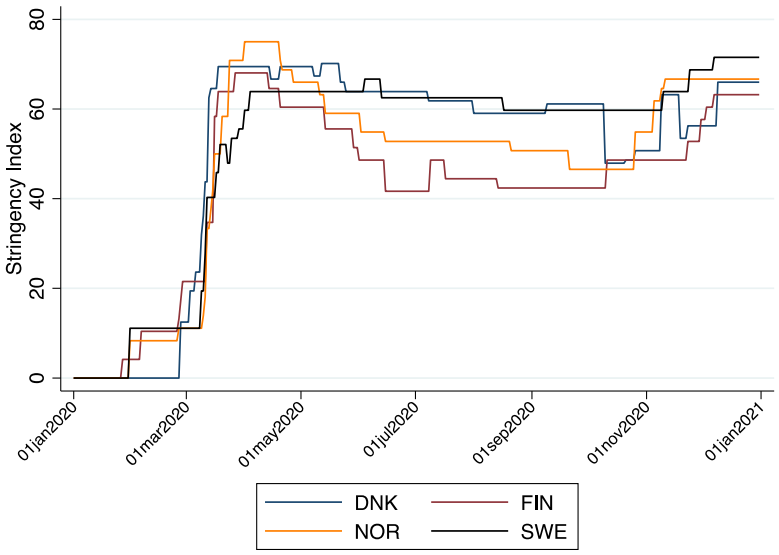

Fig. 4a. Stringency index: Denmark, Finland, Norway and Sweden.

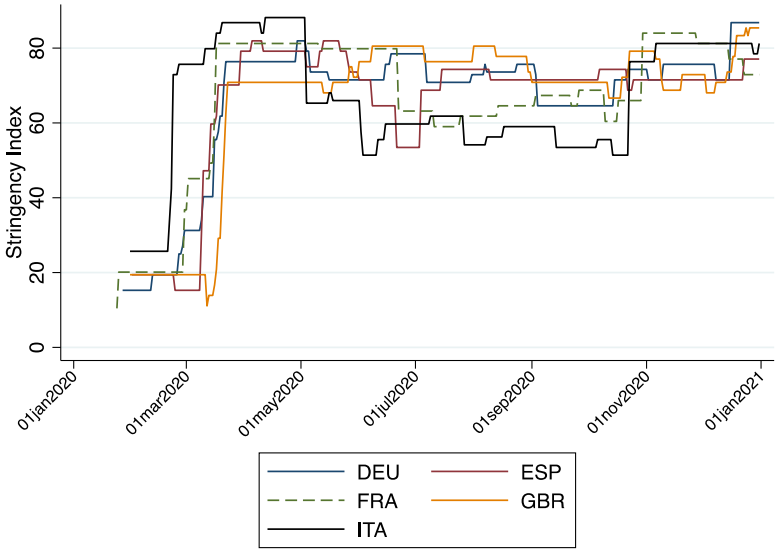

Fig. 4b. Stringency index: France, Germany, Italy, Spain, and United Kingdom.

reporting, such as during a weekend. In our model, we employ an aggregate stringency index to account for eleven individual specific government policy response measures to the pandemic (not including an international air closure sub-index).

For some Nordic countries, full international air border closure began approximately mid-March and continued up to mid-June 2020. This period saw a rise in total COVID-19 cases for all Nordic countries early in the period but for Denmark, Finland and Norway the growth in cases did flatten out by mid-April, whereas Sweden experienced a continuous rise in the number of cases (Fig. 1a). During the international air lockdown period Sweden followed a different growth path in COVID-19 cases compared to the other Nordic countries.

Our stringency index is sourced from the University of Oxford and is used to control for the general policy response during the pandemic. The individual C-category indices in the overall index are defined over government containment and closure policies, the E1 index relates to economic support policies and the H-category indices include health system polices. Table 1 provides monthly averages for the stringency policy index for the four Nordic countries for the period April through June 2020. In none of these months did Sweden show an aggregate stringency index less than other Nordic countries. In fact, Sweden is second only to Denmark in the months of May and June in overall pandemic policy response but, nonetheless, suffered major increases in total COVID-19 cases and deaths during the period of study.

Table 1
Monthly average stringency index values.

	March	April	May	June
Denmark				
Stringency[a]	47.81	63.15	62.24	64.86
International[b]	3.13	4.0	3.77	3.0
Internal[c]	0.61	1.0	0.68	0.0
Finland				
Stringency	39.76	56.26	53.25	44.94
International	3.52	4.0	3.42	3.0
Internal	0.68	1.63	0.90	0.0
Norway				
Stringency	35.57	62.14	53.62	46.52
International	2.26	4.0	4.0	3.47
Internal	1.03	1.63	1.0	1.0
Sweden				
Stringency	36.69	59.84	59.84	62.57
International	1.26	3.0	3.0	3.0
Internal	0.0	0.9	1.0	0.4

[a]Aggregate policy response index.
[b]International air closure index.
[c]Internal travel restriction index.

Our international air control measure is defined over five (0–4) groupings. The first three groups refer to no restrictions, screening, and quarantine. Group 3 indicates a ban on arrivals from some high-risk regions while group 4 indicates full international air border closure. Two binary variables are defined for international closure; DIt3 takes the value 1 for group 3 restrictions (0 otherwise) and DIt4 takes the value 1 for group 4 closure (0 otherwise). The need for the two binary controls is that Sweden did impose a group 3 restriction over most of the period of study and including DIt3 as a separate variable allows for a flexible control to include Sweden's response. Table 1 shows that Denmark, Finland and Norway imposed full border closure for most of April and May, whereas Sweden enforced a weaker, group 3 closure from April to June 2020.

There is a possible confounding issue concerning internal restrictions on travel—the Oxford index C7 is a measure of internal travel restrictions and is included in the aggregate stringency measure. The C7 measure is defined over three groups, 0, no internal travel restrictions, 1, recommended no internal travel, and 2, internal travel restrictions. At no time during the international air closure period of interest to this study did either Denmark or Sweden impose internal travel group 2 restrictions. By contrast, Norway enforced travel group 2 restrictions during April and May whereas Finland imposed internal travel restrictions for some period in May.

A possible estimation issue is that the coefficient measuring response to full air border closure (DIt4) could measure the additional control contribution relative to internal travel restrictions for Norway and Finland, but not Denmark. We respond to this issue by allowing for an individual country response to full air border closure, noting that Sweden's COVID-19 response does *not* include either group 4 air border closure or group 2 internal travel restrictions.

Our policy response model is given by Eq. (1)

$$Cases_{it} = \alpha_s + \alpha_d Den + \alpha_f Fin + \alpha_n Nor + \alpha_T Trend + \beta_4 DIt4 + \beta_3 Dit3 + \gamma_{it} Str + \varepsilon_{it} \quad (1)$$

where $Cases_{it}$ is the seven-day average growth in total cases per capita, country effects are controlled by dummies for Denmark, Finland and Norway, a time trend (*Trend*) is included to account for unobserved trending factors (e.g., weather conditions) impacting all countries over the period of analysis, *DIt4* and *DIt3* are as previously defined, and *Str* is the aggregate stringency index for country i in period t.

We assume that the error term ε_{it} satisfies Gauss–Markov conditions and is not correlated with the vector of regressors. This indicates that the decision to select air border restrictions or the aggregate stringency index in period t are *not* correlated with current values of the error term. We justify this assumption on two grounds. First, Sweden's decision not to impose full air restrictions was random in the sense that its decision was not related to its COVID-19 conditions that existed at the time but was rather a result of particular policy factors in Sweden. Second, stringency measures were imposed, at least in part, on the basis of future expectations of COVID-19 outcomes. With these assumptions, our estimation recovered consistent estimates of the parameters of Eq. (1). For robustness in estimation, we also included individual country air border closure measure and a stringency index as a response to the pandemic.

The period of estimation for each country is from the start of recorded COVID-19 cases to July 4, 2020. We do not include data for the 'second wave' of the COVID-19 pandemic because border closures were not subsequently reimposed by Nordic countries in 2020. Estimation results are reported in Table 2 with robust standards errors corrected for clustered (country) effects. Results reported in column A correspond directly to Eq. (1) and show that, controlling for country and common trend factors, the coefficients for the general stringency index and DIt3 (restricting travellers from high-risk countries) are both negative and significantly different from zero. The trend variable accounts for a small but significant negative effect over the period that affected all Nordic countries.

Table 2
Policy response model: Dependent variable = Total per capita Cases of COVID-19 (7-day average).

	A	B	C
Denmark	0.058 (0.019)	0.091 (0.000)[a]	0.351 (0.000)
Finland	−0.001 (0.976)	−0.041 (0.029)	−0.049 (0.291)
Norway	0.014 (0.679)	−0.002 (0.905)	0.012 (0.716)
Sweden[b]	0.645 (0.000)	0.665 (0.000)	0.625 (0.000)
DIt4	−0.150 (0.001)	–	–
DIt4 Denmark	–	−0.168 (0.000)	−0.109 (0.000)
DIt4 Finland	–	−0.055 (0.012)	−0.039 (0.088)
DIt4 Norway	–	−0.099 (0.000)	−0.098 (0.002)
DIt3	−0.103 (0.000)	−0.070 (0.000)	−0.048 (0.383)
Stringency	−0.004 (0.000)	−0.005 (0.000)	–
Stringency Denmark	–	–	−0.009 (0.000)
Stringency Finland	–	–	−0.005 (0.001)
Stringency Norway	–	–	−0.004 (0.000)
Stringency Sweden	–	–	−0.004 (0.000)
Trend	−0.002 (0.002)	−0.002 (0.002)	−0.002 (0.003)
Obs.	492		

[a]Robust *p*-values in parentheses.
[b]Base-reference country.

The key focus of our policy response model is DIt4, international air border closures. We find that, on average, closed air borders resulted in a significant negative effect on the growth in per capita COVID-19 cases for the three Nordic countries that implemented them. Based on our results, we conclude that Sweden suffered a 15% growth in per capita cases of COVID-19 because it did not implement an international air border closure.

Column B of Table 2 re-estimates the regression equation allowing for individual country responses to air border closure; variables DIt4 for Denmark, Finland and Norway. In all three cases, the coefficients are negative and statistically significant. The country with the largest estimated response was Denmark with a measured 16.8% decline in growth of total COVID-19 cases, Norway had a 9.9% decline and Finland had a 5.5% decrease. The coefficients should be interpreted with the knowledge that Denmark did not impose internal travel restrictions, whereas both Finland and Norway did.

We further extend the regression model in column C of Table 2 to allow for individual country effects applied to the aggregate stringency index on growth in COVID-19 cases. Our main results for the international closure coefficients (DIt4) are robust to this modification, although smaller in magnitude. The coefficients for the stringency indices are, in all cases, small but significantly negative. Sweden, with an estimated regression coefficient of similar magnitude to neighbouring countries Norway and Finland, had the benefits of reduced growth in COVID-19 cases from government policy action.

Our policy response model is robust to variation in specification and shows the effective role of international air border closure on decreasing the growth in per capita COVID-19 cases in Nordic countries. Based on our model assumptions, the estimates are consistent and have internal validity in projecting alternative policy outcomes. Thus, we evaluated two alternative policy scenarios for Sweden; (i) what would have been total COVID-19 cases if Sweden had imposed a group 4 international air border closure rather than a group 3 (restricting travellers only from high-risk countries) and (ii) an augmentation to the scenario (i) by including group 2 internal travel restrictions to the aggregate stringency index.

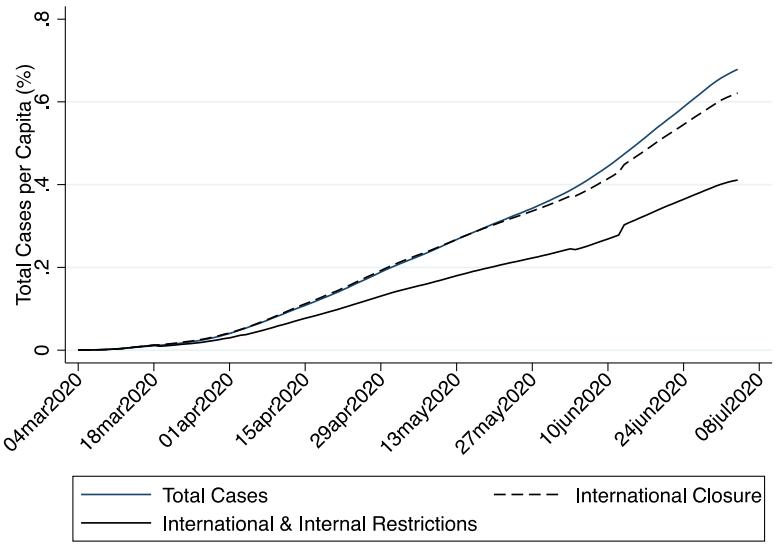

Fig. 5. Sweden: Projected total cases, two policy scenarios (seven-day average). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

For scenario (i), the variable DIt3 is replaced by an DIt4 index. Using the results reported in column B of Table 2, we projected what would have been the growth in total per capita COVID-19 cases in Sweden under the hypothetical that it had imposed an air border closure. For scenario (ii), DIt4 is maintained in the projection but the stringency index is recalibrated to include internal travel 2 restrictions. For scenario (ii), the results reported in column C of Table 2 are used to predict COVID-19 outcomes. For presentation purposes, based on predicted growth outcomes for each scenario, projected seven-day average total COVID-19 cases are recovered and graphed in Fig. 5.

The solid blue line in Fig. 5 is the reference trend showing the actual seven-day average total COVID-19 cases per capita. The dashed black line shows scenario (i), that is, the projected change in trend outcome *if* Sweden had imposed a group 4 air border closure. This line reflects a 16.8% decline in growth of total COVID-19 cases. The solid black line scenario (ii), shows the *additional* effect on the trend if Sweden had also imposed a group 2 internal travel restriction.

In sum, restricting international travellers in the early stage of the pandemic did have the desirable outcome of reducing the growth in COVID-19 cases in Nordic countries in the first half of 2020. Further, based on our policy response model, it would seem that Sweden could have reduced its per capita COVID-19 cases by imposing air travel restrictions similar to its Nordic neighbours, Finland and Norway.

3.4. Per capita COVID-19 fatalities and GDP growth

Figs. 6a and b, respectively, provide the percentage quarterly GDP change (to the previous quarter) for all quarters in 2020 and the corresponding *additional* quarterly number of COVID-19 fatalities (given by the number in the square bracket for each quarterly bar) for Nordic countries and also for large Western European countries.

Among Nordic countries, Sweden had the highest quarterly total fatalities with total fatalities (cumulative over all quarters), and also cumulative total for 2020. As of the end of December 2020, Sweden's total fatalities were 8,727 as recorded in 'Our World in Data'. Sweden's Nordic neighbours reported much lower quarterly fatalities noting that Sweden's population is about twice that of each of Denmark, Finland and Norway. All other Nordic countries had total fatalities at the end of December 2020, not exceeding 1298 (Denmark), 561 (Finland), and 436 (Norway). Total fatalities were much higher in the large Western European countries, ranging from 33,791 (Germany) to 74,159 (Italy) noting that all of these countries have much larger populations than any Nordic country.

The change in GDP between the first and second quarters was negative for all countries and varied from minus 4% and 5% for Finland and Norway, about minus 7% for Denmark, and about minus 8% for Sweden. Quarterly GDP growth increased from the second to third quarter in all Nordic countries. There were further increases in quarterly GDP from the third to the fourth quarters for all Nordic countries except Sweden which had a slight decline. Overall, there was a decline in annual GDP over 2020, relative to 2019, as follows; Denmark (−3.3%), Finland (−2.8%), Norway (−0.8%) and Sweden (−2.8%).

Fig. 7 provides a plot of 26 countries in OECD Europe in relation to the change in annual GDP from 2019 to 2020 against per capita cumulative COVID-19 fatalities. Included are all Nordic countries, the biggest Western European countries by population (France, Germany, Italy, Spain, and United Kingdom), and also Austria, Belgium, Czech Republic, Estonia, Greece, Hungary, Iceland, Ireland, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Slovak, Slovenia,

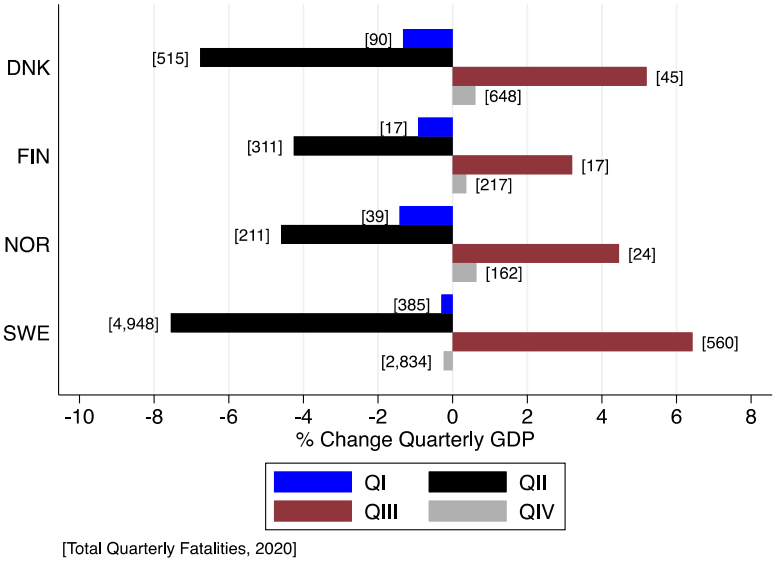

Fig. 6a. Percentage change in quarterly GDP with total quarterly cumulative fatalities: Denmark, Finland, Norway and Sweden.

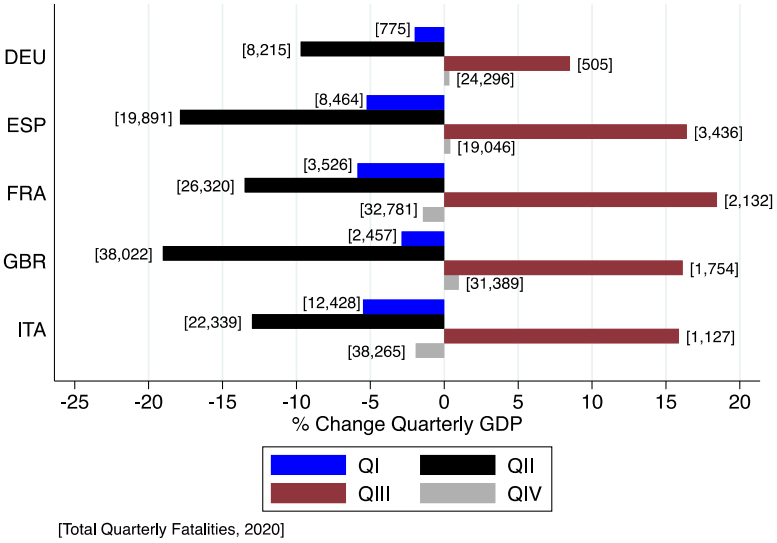

Fig. 6b. Percentage change in quarterly GDP with total quarterly cumulative fatalities: France, Germany, Italy, Spain, and United Kingdom.

and Switzerland. A regression of the change in annual GDP against per capita COVID-19 fatalities estimates a negative relationship (−0.003) that is statistically different from zero at the 5% level.

4. Discussion

Before highlighting the key findings, we acknowledge limitations to our study. First, our results only apply to the end of 2020. Second, our data are based on confirmed cases of COVID-19 that are likely to be less than actual cases (Phipps et al., 2020), and also COVID-19 fatalities (Kontis et al., 2020). This possible bias, at least in terms of case numbers, is likely to be more pronounced in countries that have had a low testing rate, such as Sweden. Third, our stringency measure of SD only account for government-related measures and do not include voluntary behaviours of individuals to avoid becoming infected, or infecting others. Fourth, in 2021 and beyond, the efficacy and effectiveness of the selected COVID-19 vaccines, and also the scale and speed with which countries deliver vaccinations to their populations, will play an increasingly important role in determining confirmed cases and fatalities that may have little association with a country's current or past effectiveness of SD measures or border closures.

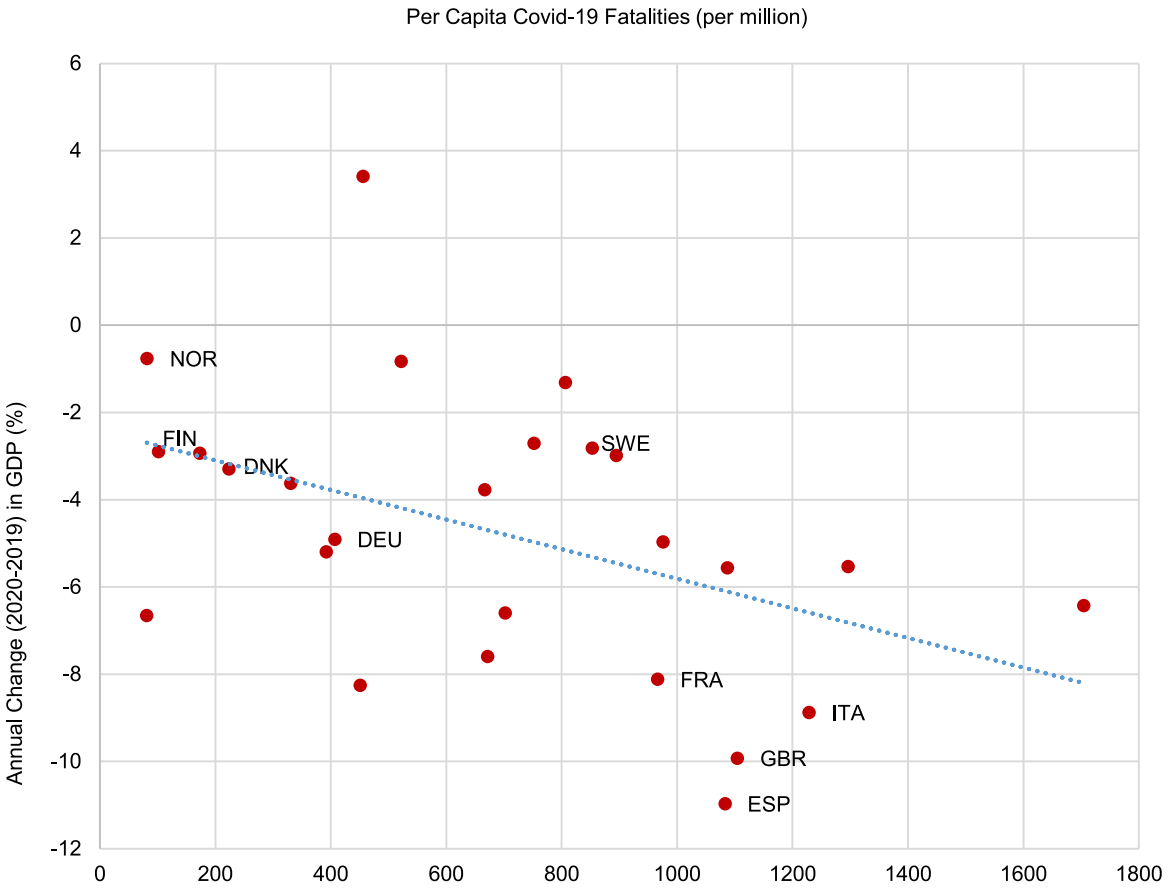

Fig. 7. OECD European countries, % change in annual GDP (2020–2019) and per capita COVID-19 Fatalities (per million) as of 31/12/2020. *Notes on trend line*: 1. % Δ GDP (2020–2019), country $_i$ = −2.416331 - 0.0033959 ∗ Per Capita COVID-19, country $_i$ ($p = 0.042$) ($p = 0.023$) 2. Prob. > $F = 0.0226$.

While variations exist among the Nordic countries, including in terms of trust in government (Helsingen et al., 2020), the selection of neighbouring Nordic countries ensured, as much as possible, like-with-like national comparisons and reduced the effects of key cross-country differences such as quality of health care, welfare payments, per capita income, capacity of government, education, demography and geography. Based on analysis of trends from 1 January to 31 December 2020, we find that Sweden's public health outcomes, in terms of per capita cases and fatalities from COVID-19, were substantially worse than in its Nordic neighbours.

We find two plausible factors for the differences in public health outcomes in terms of COVID-19 among Nordic countries. First, Sweden had a much lower rate of testing for COVID-19 compared to its peers. A lower testing rate reduces the efficacy of contact tracing that, in turn, contributes to higher number of infections (Gardner and Kilpatrick, 2020; Keeling et al., 2020) for any given level of SD (mandated or voluntary). Second, a more open border in Sweden, relative to its Nordic neighbours, in the early months of the pandemic likely contributed to greater growth in per capita COVID-19 cases and, subsequently, higher per capita COVID-19 fatalities. Such a finding was also identified for Ireland as international travel early in the pandemic was its primary source of transmission (Conway et al., 2021).

Cross-country economic comparisons and forecasts (Jena et al., 2021) are problematic in that multiple factors, other than public health outcomes alone, contribute to a better or worse economic performance. Further, economic performance itself is multi-faceted and not limited to only changes in GDP (Padhan and Prabheesh, 2021; Tisdell, 2020). With these caveats we find that for OECD European countries there is a statistically significant and negative relationship between the percentage change in annual GDP between 2019 and 2020 and per capita COVID-19 fatalities in 2020. With the exception of Sweden, all Nordic countries performed relatively well compared to large Western European countries in terms of per capita fatalities and the percentage decline in GDP in 2020.

Notwithstanding the limitations of our study, an important public health implication of our findings is that early imposition of full international travel restrictions appears to have reduced the growth in per capita cases (and, thus, per capita fatalities) associated with COVID-19 in Nordic countries in 2020. This is an important result of policy significance to other countries given that the World Health Organisation (WHO) has advised "...against the application of travel or

trade restrictions to countries experiencing COVID-19 outbreaks" (WHO, 2020b) and ". . .does not recommend travellers as a priority group for testing" (WHO, 2020c).

5. Conclusions

Since the start of the COVID-19 pandemic, officially declared by the WHO on 11 March 2020, many countries have struggled to determine the desirable timing, scale and selection of policy responses to control the disease. Large, cross-country studies are now available that show that earlier implementation of more stringent SD measures is associated with lower per capita COVID-19 cases (Islam et al., 2020).

We contribute to the existing literature on the effectiveness of alternative policy responses to COVID-19 with 'like-with-like' country comparisons of the public health and economic outcomes associated with different control measures and, in particular, national air border closures. We also track over 2020 the public health and responses across groups of countries that have some similar characteristics, such as between Nordic countries and large Western European countries, to compare the cross-country effects of COVID-19.

In a policy response model of Nordic countries, we find that Sweden's decision *not* to impose an air border closure in the 'first wave' of the pandemic in the first half of 2020, in part, explains its poor performance relative to its Nordic neighbours in terms of the growth in per capita COVID-19 cases and fatalities. Comparisons of changes in quarterly GDP for Nordic countries and large Western European nations, and a regression using data from OECD European countries of cumulative per capita COVID-19 fatalities on the percentage change in annual GDP from 2019 to 2020, also provide insights about the relationship between public health outcomes in relation to COVID-19 and national economic performance. These comparisons suggest that, in 2020, a poorer public health performance in terms of COVID-19 was associated with lower economic growth.

A key implication of our study is that, at least for Nordic countries, the imposition of effective air border closures in the first half of 2020 reduced the growth in per capita COVID-19 cases. Our finding, at least from a public health perspective, is contrary to the WHO advice that countries should not close their borders and treat arrivals, in terms of testing for COVID-19, no differently to residents. A second policy insight is that, at least for OECD Europe in 2020, a poorer public health performance with respect to cumulative COVID-19 fatalities is associated with a worse economic performance. Thus, at an aggregative level, we do *not* find a discernible trade-off between the implementation of national measures that successfully controlled the growth in COVID-19 cases and overall economic growth.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.eap.2021.04.015.

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