RESEARCH REPORT SERIES
ISSN 2785-0781

Number 13
NOVEMBER 2023

# COST-EFFECTIVENESS ASSESSMENT OF GOVERNMENT RESPONSE POLICIES AGAINST COVID-19

Edoardo Croci

Annamaria Bagaini

Enrico Alessandri

Università Bocconi
GREEN
Centre for Geography, Resources, Environment, Energy and Networks

**Research Report Serie**

**Cost-effectiveness assessment of government response policies against COVID-19**

Edoardo Croci (scientific coordinator),

Annamaria Bagaini,

Enrico Alessandri

The project report is part of CoronaDX Horizon 2020 project (n. grant 101003562).

Keywords: Covid-19 government policy responses; Cost-effectiveness analysis; Socio-economic impact; Health impact; Environmental co-benefits

Horizon 2020 Contract Nº 101003562


# Three Rapid Diagnostic tests (Point-of-Care) for COVID-19 Coronavirus, improving epidemic preparedness, and foster public health and socio-economic benefits

Deliverable report

| | |
|---|---|
| Deliverable number | D7.4 |
| WP no/title | WP7 - Public Health Response and Socioeconomic Impacts |
| Deliverable title | Impact of the 2019-nCOV epidemics on the world economy |
| Responsible partner | UNISR (UniPV and UB as third party) |
| Authors | Edoardo Croci (scientific coordinator), Annamaria Bagaini, Enrico Alessandri |

**Table of contents**



# List of Figures

## List of Tables

# 1 Introduction

In December 2019, the Covid-19 pandemic broke out in Wuhan, Hubei Province, China. Since then, it has become a fully-fledged pandemic that has rapidly swept through many countries (Jebril, 2020; Lu et al., 2020). Covid-19 moved from China to Europe on early March 2020 (WHO, 2020c) becoming, according to the World Health Organization (WHO) (2020a; 2020b), a worldwide "pandemic public health menace". The pandemic caused globally 430,257,564 confirmed cases and 5,922,047 confirmed deaths since the beginning of the pandemic[1]. The high level of interconnectedness and movement of people and the high transmissibility of the SARS-CoV-2 virus (Greenhalg et al., 2021) facilitated the rapid spread of Covid-19 across the globe and related impact on human health, economics and even environment conditions. From early 2020 to late 2021, the world has experienced four waves of Covid-19. The first wave took place between early 2020 and late spring 2020, when the infection moved from China to Europe. Italy was the first European nation to experience a major outbreak in spring 2020[2], becoming the first country in Europe to introduce a national lockdown (Saglietto et al., 2020). The second wave of Covid-19 pandemic started after summer 2020 and took place between autumn 2020 and the first months of 2021, aggravated by the presence of new SARS-CoV-2 virus variants. Indeed, during two years of Covid-19 pandemic, several virus variants emerged, with an increase in transmission capacity and related human risks. For instance, the Alpha and Delta variants were more transmissible than the original virus identified in Wuhan, China[3] (Tregoning et al., 2021). The second wave of Covid-19 epidemic hit a larger number of countries worldwide than the first one, including many European countries, the US and Latin America (especially Brazil) (Hafeez et al., 2021). After a reduction of Covid-19 cases and deaths globally between late spring and early summer 2021 - thanks to the vaccination campaign – Covid-19 cases and deaths restarted to rise worldwide in July 2021. This new worsening of Covid-19 pandemic characterized the third wave, and the main driver was the Delta (Indian) variant firstly identified in India in December 2020 (Kupferschmidt and Wadman, 2021). The Delta variant was diffused in more than 111 countries in July 2021, and it became the dominant Covid-19 variant circulating worldwide[4], being particularly severe in India, the United Kingdom, South East Asia and several European countries. The third wave of Covid-19 pandemic lasted from July to early autumn 2021 and has been followed (almost immediately) by the emergence of a fourth wave from November 2021 onwards. During the fourth wave, the Delta variant continued to drive new waves of infection and remained the dominant Covid-19 variant in many countries. However, between November and December 2021 - the fourth wave has been aggravated – or led by – the emergence of the Omicron[5] variant of SARS-CoV-2 virus, which was firstly detected in Botswana on 11th November 2021. This variant quickly spread all over the world, considering its high transmissibility and partial hypothesized resistance to Covid-19 vaccines (Karim and Karim, 2021). Omicron joins Delta, Alpha, Beta and Gamma on the current WHO list of variants of concern[6]. Omicron variant has become the dominant variant – co-existing with the Delta one -, spreading around the world, especially across Europe (He et al., 2021).

The outbreak of Covid-19 generated impacts on many and different dimensions, such as on human health, economic activities, society and environment. The intensity of the impact is inherently linked

[1] https://covid19.who.int/

[2] Followed by the United Kingdom.

[3] SARS-CoV-2 variants of concern are able to mutate so that they can continue spreading in the face of rising population immunity while maintaining their replication fitness.

[4] https://news.un.org/en/story/2021/07/1095882

[5] https://www.cdc.gov/coronavirus/2019-ncov/variants/omicron-variant.html

[6] who.int/news/item/28-11-2021-update-on-omicron

to pre-pandemic national population composition, social and economic conditions, labour market and industrial structure, as well as government response implemented to react to the crisis. The impact of the pandemic on human health may regard the excess deaths, which captures not only Covid-19 confirmed deaths, but also Covid-19 deaths that were not diagnosed and reported as well as deaths attributable to the overall crisis conditions. For instance, while 1,813,188 Covid-19 deaths were reported globally in 2020, recent WHO (2021b) suggests an excess mortality of at least 3,000,000 in year 2020. Another relevant health impact of the pandemic is the impact on mental human health. Measures such as self-isolation and quarantine have affected usual activities, routines of people that may lead to increased loneliness, anxiety, depression, harmful alcohol and suicidal behaviour (Kumar and Rajasekharan, 2020). Covid-19 pandemic had devastating impacts also on economic activities (Dosi, Fanti and Virgillito, 2020; Emmerling et al., 2021). The pandemic reduced global economic growth in terms of Gross Domestic Product (GDP) to an annualized rate of -4.5% to -6.0% in 2020, with a partial recovery of 2.5% to 5.2% by the end of 2021. The recovery is envisioned to continue into 2022, with global GDP that is expected to remain 1.8 percent below pre-pandemic projections (OECD, 2021a). Compared to recoveries from previous global recessions, the current crisis is more complex, with per capita GDP in many emerging countries remaining below pre-pandemic levels for an extended period. Major advanced economies, which comprise 60% of global economic activity, are projected to operate below their potential output level through at least 2024 (CRS, 2021a). Socioeconomic impacts also refer to poverty level raising, careers derailed and social unrest increases. Estimates indicate that 95 million people may have entered into extreme poverty in 2020 with 80 million more people undernourished compared to pre-pandemic levels (CRS, 2021b). Furthermore, the pandemic has worsened gender inequality issues. For instance, lockdown situations exacerbate risks of violence, exploitation, abuse or harassment against women, as has been seen from previous crises (OECD, 2020b). Concerning the environmental impact of Covid-19 pandemic, a substantial decline in energy has been observed in countries that followed complete or partial lockdown measures. For instance, electricity demand during Covid-19 was at least 10% lower in comparison to pre-Covid-19 times at the global level (Mousazadeh et al., 2021). Another major and immediate positive environmental impact (co-benefit) of the lockdown refers to the reduction of air pollution, especially in more industrialized countries.

Those consequences hit countries with different intensities worldwide. The intensity and variety of impacts are directly linked to the type of policy responses adopted to address health and socio-economic problems. Policies have been designed to find a balance between reducing health risks and allowing economic activities. Initially, policymakers were unprepared and overwhelmed by the quickly changing nature of the global health crisis and the immediate economic effects (Pianta, 2021). Indeed, Covid-19 policy responses strongly varied worldwide at the beginning of the outbreak. Then governments started to follow a similar path to fight the crisis. It is possible to distinguish policy strategies into three groups: containment policies, economic policies and health policies. Containment policies entail school and workplace closures, restrictions on public gatherings and national or international movement, stay at home requirements (Hale et al., 2021). Most recently a new containment strategy emerged: the Digital documentation of Covid-19 certificates which allows vaccinated people to access social activities, limiting the virus spread. The most adopted containment policy refers to the lockdown. Lockdown includes several government restrictions on activity that dramatically reduce mobility and social interaction, including working activities (Miles, Stedman and Heald, 2020). A second type of policy responses entails economic policies (Devereux et al., 2020). The most relevant economic policies concern income support[7] – to households –, and debt or contract

[7] Universal basic income.

relief[8] – to enterprises – (Hale et al., 2021). International organizations also took steps to provide loans and other financial assistance to countries in need. These and other actions have been labelled "unprecedented", a term that has been used frequently to describe the pandemic and the policy responses. For instance, the "Next Generation EU" plan worth 806.9 billion euros aims to help the recovery of the economic and social damage brought on by the coronavirus pandemic on countries belonging to the eurozone[9]. The plan has three specific goals: promote digitalization, promote resilience, and promote a more environmentally sustainable economic development model. Effects of these plans will be clear only in the long term since the Next Generation EU plan covers 6 years of investments, from 2021 to 2026. A third set of governmental policy responses relates to health policies, which include testing, contact tracing, face coverings, public information campaigns, social distancing and vaccination campaign.

The policy responses had different and combined direct and indirect impacts on human health, economy, society and environment. Regarding direct impacts, containment policies have contributed to saving lives by reducing Covid-19 diffusion among the population (Barro, Ursua and Weng, 2020) and, at the same time, they have led to unprecedented economic losses in the short term. Economic policies reduced economic impacts caused by the outbreak. However, short term recovery measures (e.g., increasing government spending) could lead to debt accumulation with long-term impacts on national economies. Health policies have direct impacts on human health by contributing to the reduction of SARS-CoV-2 diffusion and Covid-19 deaths. For instance, testing, combined with effective contact tracing, are key components of post-lockdown strategies, especially at relatively low level of infections (OECD, 2020a), but they require high citizen awareness and high performing digital and physical infrastructures to manage data and provide responses. A recent outbreak modelling study (Hellewell et al., 2020) found that contact tracing and isolation would only contain outbreaks of Covid-19 if very high levels of contact tracing were achieved. Many countries have struggled to roll-out comprehensive testing regimes and contact tracing becomes more difficult at higher levels of infections. So far, the most relevant health policy to fight Covid-19 pandemic is the vaccination campaign (Liu et al., 2021). Extraordinary efforts and resources have been committed to the development and roll-out of Covid-19 vaccines and vaccination programs. These global efforts have led to vaccine development at an unprecedented speed (Pieroni, Facchini and Riccaboni, 2021) with an effective impact in reducing deaths and hospitalizations. However, policy responses may have indirect impacts on environment and health. Regarding the environmental impacts, containment policies have led to a temporary improvement of local air quality, which is a co-benefit of lockdown measures (Granella et al., 2020). Health policies (co)benefits refer to the reduced transmission of other viruses such as the Influenza virus due to the wide use of face masks (Martin et al., 2020). Covid-19 pandemic has also generated indirect (co)damages to human health. For instance, the care shift and the reduction of healthcare services for patients who have other diseases, e.g., cancer, cardiovascular illnesses. Specifically, for patients without Covid-19 infections, it is worth mentioning pre and in-hospital delays, reduced access to medical care for fear of contagion, shortened diagnostic protocols because of hospital congestion and withdrawal of important therapies (Gori et al., 2020).

This study aims to assess socio-economic impacts of Covid-19 epidemics by quantifying direct and indirect costs and effects coming from pandemic response policies and measures at the European level. The main goal is to evaluate the cost-effectiveness of policies responses adopted to fight the crisis and support stakeholders and decision-makers in responding to outbreak situations. Covid-19

[8] Delayed repayments, rescheduling payment for loans or rents, credit guarantees, state-guaranteed loans, capital buffer safeguards. Specifically, capital buffer safeguards refer to lowering capital requirements on banks to increase lending to companies.

[9] https://ec.europa.eu/info/strategy/recovery-plan-europe_en

policy and measures are assessed through a cost-effectiveness analysis (CEA, Bleichrodt and Quiggin, 1999; Deb et al., 2020). CEA is a method to examine and compare monetized costs and effects of one or more interventions, policies and measures (Robinson, 1993; Vandepitte et al., 2021). These policies and measures are cost-effective when overall monetized effects overcome overall monetized costs. CEA is often used in the field of health services, where it may be too difficult to monetize health effects (OECD, 2018) generated by a complex mix of public interventions. The effectiveness of Covid-19 policy responses has been assessed considering the mix of policies and measures adopted by five countries, namely Denmark, Italy, Israel, Sweden and the United Kingdom, looking at social, economic, health and environmental impacts. The analysis has been conducted considering two-years' time frame, i.e. from 2020 to 2021. The time frame has been selected according to data availability, although Covid-19 outbreak is far from over. Indeed, in 2022 the Omicron variant led to a massive surge of Covid-19 cases, especially among more vulnerable and higher risk groups. According to WHO (2022), Covid-19 virus is an unstable virus that changes rapidly and limits our ability to predict the future evolution. Despite uncertainties, the transition from pandemic to endemic phase seems realistic. Epidemiologically, Covid-19 can be defined as endemic when it exists at a predictable level that does not require society-defining interventions (CDC, 2021b). The risk of new variants emerging is related to the number of cases in the world since each infected individual represents a new opportunity for viral evolution. For this reason, the continued global rollout of Covid-19 vaccines remains an investment in our collective safety as well as an imperative to protect individuals[10].

Study cases have been selected according to their heterogeneous pandemic evolutions and effects. Our selection criteria relate to policy responses stringency level, economic and health impacts. In particular, we chose Italy due to the pandemic strong impacts on human health and economy, and its severe and prolonged lockdown. Sweden did not opt for a nationwide lockdown, which represents a unique case in the EU. Denmark adopted only soft containment policies to cope with the epidemic. Israel is an interesting country due to the early vaccination campaign compared to other OECD countries, which made it a living lab of vaccine effectiveness in contrasting the pandemic. The United Kingdom has been chosen because of the heavy impact on human health during almost all waves. Moreover, the United Kingdom adopted Covid-19 response policies later than many OECD countries, making this country an interesting case for the comparative assessment of policy cost-effectiveness.

In order to assess the effectiveness of different policy responses we developed a four steps methodological approach. Firstly, we identified statistical relationships between policy responses (i.e. containment, economic support and health policies) and health or socio-economic impacts to identify their interdependence. A statistical relationship (or relationship) exists if a change in one variable X results in a systematic variation in another variable Y (Agresti, 2018). It is similar to correlation analysis. The main difference is that correlation analysis is a method of assessing a possible two-way association between two variables in an exact moment in time (e.g. one quarter) (Stock and Watson, 2015); while a statistical relationship assesses a possible two-way association between two variables over time (e.g. over quarters) (Agresti, 2018). Then, statistical relationships have been evaluated by looking at their relevance, which describes policies' capacity to generate effects on economic, health and environmental dynamics. Statistical relationships are relevant when direct relationship between policy responses and socio-economic, health and environmental variables are observed over time (for example, when policy responses have been effective in mitigating socio-economic and health impacts). Finally, we defined national policy response models by evaluating the stringency of policies and

[10] https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/when-will-the-covid-19-pandemic-end

measures implemented in each study case. For each national policy response model, we evaluate the cost-effectiveness, by identifying and attributing monetary values to costs and effects generated by policy responses in each country.

This study is part of CoronaDX Horizon 2020 project (n. grant 101003562). The general objective of CoronaDX project is to develop Point of care diagnostic tools for fast case detection and surveillance fostering public health response (e.g. advanced testing policies) to contain the epidemic threat of Covid-19. This project involves international partners with multidisciplinary backgrounds: Danmarks Tekniske Universitet (DTU), Medizinische Universitaet Wien (MUW), Statens Serum Institut (SSI), Tataa Biocenter Ab (TATAA), Sun Yat-Sen University (SYSU), Università Vita-Salute San Raffaele (UNISR) with Bocconi University as third party for Task 7.4, Fondazione Icons (ICONS), National Institute for Viral Disease Control and Prevention, Chinese Center for Disease Control and Prevention (CCDC).

The report is organized in seven sections. Section 2 defines Covid-19 policies response categories and conceptual framework. Sections 3 describes the methodological approach utilized. Section 4 resumes results coming from the comparative analysis of socio-economic, health and environmental impacts generated by the pandemic in the five case studies. Section 5 provides results of the statistical relationship assessment between Covid-19 policy responses and socio-economic, health and environmental impacts. Section 6 assesses the relevance of statistical relationships between policy responses and socio-economic, health and environmental variables. Section 7 identifies and describes national policy response models. Section 8 provides results of the cost-effectiveness assessment of the five national policy response models.

# 2 Conceptual frameworks on government response policies to the pandemic

During two years of Covid-19 pandemic, several policy responses have been implemented worldwide to fight the crises. Countries characterized by different institutional setup and pandemic consequences have reacted very differently in terms of crisis management. Different policy responses can bring to different impacts on socio-economic, environmental and health variables, and different degrees of costs and effectiveness. We divide government policy responses to Covid-19 outbreak into three groups: containment policies, economic policies - supporting households and enterprises -, and health policies.

Containment policies include all measures aimed at reducing virus transmission, like lockdowns and restrictions in social activities and mobility (Hale et al., 2021). The International Monetary Fund (IMF, 2020) has shown that overall containment policies have a positive impact in reducing virus transmission but also generated dramatic economic and social impacts. For example, a lockdown measure can have extensive effects on the economy, which can be local or international, generally increasing individual costs and work disruptions. Broadly restricting the capacity of citizens and organizations to operate, work and travel mean accepting that an economy will contract significantly, jobs will be lost and major uncertainties will emerge in the world economy (Nicola et al., 2020). Furthermore, several studies (see e.g. Chinazzi et al., 2020; Errett et al., 2020) have put in doubt the usefulness of some containment measures (i.e. travel restrictions such as airport closures, interruption of flights and movement of people). Travel restrictions have been (almost) always adopted too late to stop new SARS-CoV-2 variants originating abroad. Travel bans also create a stigma towards some countries which may bring to not declare new variants, in the fear of being penalized with the isolation that involves high costs compared to benefits occurring in other countries. Worldwide the most

recurring containment measure has been the lockdown. According to IEA (2020) in 2020, about 4.2 billion people (54% of the global population, representing almost 60% of global GDP) were subject to complete or partial lockdowns and nearly all the global population was affected by some form of containment measures (IEA (2020a). Lockdown measures include social distancing, school and workplace closures, travel bans, prohibition of sporting events and other mass gatherings, mobility restrictions, and stay at home requirements. Although the lockdown was adopted worldwide (Hale et al., 2021), the strictness of this measure strongly varies among countries (Fernandes, 2020; OECD, 2021a). Digital documentation of Covid-19 certificates (in the EU also known as Green Pass) has been also included in this category of policy response. Certifications serve as proof that a person was vaccinated against Covid-19, received a negative test result or recovered from Covid-19. Italy can be considered a high representative case for containment policy responses. Facing a decaying and under-financed national health system, the policy action in Italy has been a generalized lockdown (Signorelli, Scognamiglio and Odone, 2020). Italy is also an example of the strict adoption of the Digital Covid-19 Certificate since its introduction at the European level (from 1st July 2021). In Italy, the Green Pass is becoming the key measure for containing the infection and fostering the vaccination campaign. It is compulsory to access indoor restaurants, pubs, for long-distance public transport and to attend public events[11]. Recently, in some European countries, the use of compulsory EU Digital Covid-19 Certificate[12] – also known as Green Pass - has incentivized a greater number of people to get vaccinated, but it also produced social unrest such as protests in many towns[13]. However, tensions emerged even earlier the introduction of the Green Pass, as a consequence of limiting individual choice through other health policies (e.g. wearing masks) and lockdowns (Capano, 2020).

Economic support policies have been usually implemented along with containment policies, in order to lessen the damages on economic activities and families' incomes (Devereux et al., 2020). Economic support policies concern income support and debt or contract relief. Income support measures cover losing salaries and provide direct cash payments, e.g., universal basic income measures for people who lose jobs or cannot work. Debt or contract relief measures aim at supporting companies and businesses by freezing financial obligations during the Covid-19 pandemic, stopping loan repayments, preventing services like water from stopping or banning evictions (Hale et al., 2021). In our sample, the United Kingdom represents an interesting example in terms of economic policy responses. Its "extraordinary" package of economic support has been allocated from the initial stages of the pandemic onwards at a relatively regular rate. For instance, during the first wave, the UK government provided 5 billion of pounds to support smaller businesses that were facing collapse because of cash flow problems or because of staff absence during the outbreak. Moreover, the UK government allocated additional funding of 500 million of pounds to help self-employed and workers in the "gig economy", who are ineligible for statutory payments (Mitha, 2020). While having positive impacts in terms of preventing closures of businesses and stabilizing demand of goods and services, economic support policies may have negative impacts concerning the increased national spending and, thus, an augmented public debt (Guerrieri et al., 2020). However, in long term economic support policies may generate wide social benefits, which are now hard to estimate.

---

11 https://www.salute.gov.it/portale/nuovocoronavirus/dettaglioNotizieNuovoCoronavirus.jsp?lingua=english&menu=notizie&p=dalministero&id=5531

12 https://ec.europa.eu/info/policies/justice-and-fundamental-rights/eu-citizenship/movement-and-residence/eu-digital-covid-certificate-vaccinations-and-travel-restrictions_en

13 This can be considered a negative impact of vaccination measure.

The third group of Covid-19 policy responses regards health policies that entail social distancing, testing, contact tracing, face coverings and vaccination campaign (Hale et al., 2021). Social distancing consists of a set of measures intended to prevent the spread of a contagious disease by maintaining a physical distance between people and reducing the number of times people come into close contact with each other (Painter and Qiu, 2020). Distance differs from country to country and can change as time goes by, following the pandemic waves and peaks. Testing measure refers to all typologies of testing against Covid-19, namely diagnostic testing[14] and antibody testing[15]. Although testing can be carried out quickly and on a truly mass scale, testing also needs to be accompanied by tracing activities to discover clusters of infections (Egert, 2020). Contact tracing – along with robust testing, isolation and care of cases – is a key strategy for interrupting chains of transmission of SARS-CoV-2 and reducing Covid-19-associated mortality (WHO, 2021; Panovska-Griffiths et al., 2020). The effectiveness of testing and tracing crucially depends on the coverage of direct contacts and the speed with which the tests are carried out and infected people identified and treated (Hellewell et al., 2020). For instance, many countries encountered difficulties in rolling out comprehensive testing regimes and contact tracing strategies become more difficult at higher levels of infections (Hellewell et al., 2020). Providing some emblematic examples of countries successfully adopting health policies, the United Kingdom opted for a well-organized contact tracing measure (Fetzer and Graeber, 2021). The strength of the United Kingdom in tracing people is not solely linked to the ability to reach people by using telephone numbers and digital tools, but the UK government was also able to aid isolated people by setting up support networks, especially for vulnerable groups[16]. A worldwide adopted health policy regards face coverings. Face covering refers to the use of face masks outside of homes (Brooks et al., 2021). Many studies (see e.g. Robinson et al., 2020; Wang and Otani, 2013) find that face masks remove the majority of viral aerosols. Moreover, the masks are more effective with decreasing viral loads. Indeed, when transmission by submicron aerosols[17] is possible, masks can only partially reduce the risk of infection (Robinson et al., 2020). The efficacy of facial coverings also depends on the type of face mask worn (Greenhalgh et al., 2020) and on the strictness of this measure (Hale et al., 2021). A higher effectiveness of face coverings is often detected when face masks are compulsory in all indoor places or in all outdoor and indoor places outside home. Conversely, face masks are less effective in reducing Covid-19 cases when they are simply recommended or required in some public (indoor) spaces (Sunjaya and Jenkins, 2020). In our sample, Italy is a good example of facial coverings health measures. Wearing a face mask has been mandatory in indoor spaces since the first wave of the pandemic; additionally, face masks were compulsory even in outdoor places during the pandemic peak periods. For instance, Zhang et al. (2020) find that face covering reduced the number of infections by over 75,000 in Italy from 6th April to 9th May 2020. However, the most relevant measure among health policies is the vaccination campaign. The emergence of SARS-CoV-2 has experienced the rapid development, licensure and roll-out of several Covid-19 vaccines from late 2020 onwards, initially targeting select groups including those at higher risk of severe disease, in particular older adults. The most commonly commercialized vaccines against Covid-19 are: mRNA vaccines and Adenovirus vector vaccines. mRNA vaccines include the Pfizer-BioNTech and Moderna vaccines that have been developed using RNA to stimulate an immune response[18]. The Adenovirus vector vaccines are non-

[14] Diagnostic tests are divided in antigen tests and molecular/PCR tests. Antigen tests are taken with a nasal or throat swab and detect a protein that is part of the coronavirus; these tests are particularly useful for identifying a person who is at or near peak infection (the downside is that they can be less accurate than molecular tests). Molecular/PCR tests detect genetic material (the RNA) of the Coronavirus and are sensitive enough to need only a very tiny amount of it. https://www.who.int/publications/i/item/WHO-2019-nCoV-Surveillance_Case_Definition-2020.2

[15] https://health.ucdavis.edu/health-news/newsroom/different-types-of-covid-19-tests-explained/2020/11

[16] https://www.local.gov.uk/our-support/coronavirus-information-councils/covid-19-good-council-practice/covid-19-local-contact

[17] This refers to very fine droplets that may be able to pass through the face mask (Robinson et al., 2020).

[18] https://www.cdc.gov/coronavirus/2019-ncov/vaccines/different-vaccines/mrna.html

replicating viral vector vaccines, using an adenovirus shell containing DNA that encodes a SARS-CoV-2 protein (Vanaparthy et al., 2021). Vaccines of this last type are the Vaxzevria Oxford-AstraZeneca Covid-19 vaccine, the Sputnik V Covid-19 vaccine, Convidecia and the Janssen Covid-19 vaccine. There are differences among types of Covid-19 vaccines approved in Western (Europe and USA) and Eastern countries (China and Russia). In Eastern countries, e.g. in China there are seven national approved vaccines[19], which strongly differ from western countries where similarities in the vaccine approval process exist. Chinese and Russian vaccines are also exported in many South American and African countries, becoming a means for geopolitical action. In western countries, the European Medical Agency (EMA) approved 4 Covid-19 vaccines: Vaxzevria (ex. Oxford-Astrazeneca), Comirnaty (Pfizer-BioNTech), Spikevax (Moderna vaccine), Janssen Covid-19 vaccine[20] and Nuvaxovid[21]. The Food & Drug Administration (FDA) in the United States approved 3 Covid-19 vaccines[22]: Pfizer-BioNTech, Spikevax (Moderna vaccine) and Janssen Covid-19 vaccine. It is widely recognized that vaccination has a positive impact in reducing Covid-19 risk of hospitalization and death. According to literature (Liu et al., 2021; Cylus et al., 2021), death rate among the vaccinated is 5 times lower than among the unvaccinated. The low supply conditions that occurred during the first waves led many regions to adopt prioritization strategies for Covid-19 vaccination campaigns. Besides prioritizing healthcare workers with elevated exposure risks, many countries have also been recommended to implement age-based vaccine prioritization strategies targeting older adults (WHO, 2020d). A booster of Covid-19 vaccine is now administering in many western countries, due to Delta and Omicron variants. Israel can be considered as a living lab for testing the effectiveness of vaccines, considering the early launch of the vaccination campaign compared to other countries. The national vaccination campaign has led Israel to have one of the highest rates of vaccinated individuals per capita, with 68.7% and 48% of the population having received the first or the second vaccine dose on 24th February 2021 (Rossman et al., 2021). Furthermore, Israel was the first country to start the administration of the booster doses[23]. Relatedly, Barda et al. (2021) find that, in the case of Israel, the booster dose is 93% effective in preventing Covid-19-related hospitalization and 81% in preventing Covid-19 deaths. However, vaccines are often not affordable for developing and low-income countries, where just 4% of people are vaccinated (WHO, 2021a).

The three groups of Covid-19 policy responses (containment, economic support and health policies) generated positive and negative impacts on socio-economic, health and environmental dimensions. A mix of these[24] have been used for balancing economic costs and health risks related to the pandemic, and reducing side-effects, even in terms of population acceptance. Indeed, policy categories and related measures are never implemented alone. This mix or package (Silva et al., 2015) strongly vary among countries, being mediated by political, cultural, economic and historical national backgrounds (Tyshenko and Paterson, 2010).

---

[19] Eastern countries vaccines: Sinopharm BIBP approved on 31st December 2020, Coronavac approved on 5th February 2021, Sinopharm WIBC approved on 25th February 2021, KCONVAC approved on 14th May 2021, Covidful approved 9th June 2021, Convidecia approved 25th February 2021 and ZIFIVAX approved on 10th March 2021.

[20] Nuvaxovid (by the American company "Novavax") is currently the fifth vaccine recommended in the EU for preventing COVID-19. It is a protein-based vaccine and, together with the already authorized vaccines, will support vaccination campaigns in EU Member States during a crucial phase of the pandemic.

[21] EU vaccines: Vaxzevria (ex Oxford-Astrazeneca) Covid-19 vaccine approved on 29th January 2021, Comirnaty (Pfizer-BioNTech) vaccine on 21st December 2020, Spikevax (Moderna vaccine) on 6th January 2021, Janssen Covid-19 vaccine on 11th March 2021 and Nuvaxovid approved on 20th December 2021. https://www.ema.europa.eu/en/news/ema-recommends-nuvaxovid-authorisation-eu

[22] USA vaccines: Pfizer-BioNTech approved on 23rd August 2021, Spikevax (Moderna vaccine) on 18th December 2020 and Janssen Covid-19 vaccine approved on 27th February 2021. https://www.fda.gov/emergency-preparedness-and-response/coronavirus-disease-2019-covid-19/covid-19-vaccines

[23] https://www.timesofisrael.com/israel-becomes-first-country-in-world-to-offer-covid-boosters-to-over-50s/

[24] This refers to a specific policy mix that combine containment, economic and health policies in a cost-effective way.

This report aims to examine the impact of Covid-19 policy responses on health, socio-economic and environmental dimensions for five selected countries, i.e. Denmark, Israel, Italy, Sweden and the United Kingdom, using a cost-effectiveness approach (Bleichrodt and Quiggin, 1999; Deb et al., 2020). This provides insights to decision-makers and increases their awareness for better reacting in outbreak situations.

# 3 Methodology

The study aims at assessing the effectiveness of three categories of Covid-19 policy responses: containment, economic and health policies. The effectiveness of those policies has been examined by looking at the capacity to minimise health risks and economic losses. This can inform the discussion on how countries can better respond to any further wave of infections or pandemics. For this intent, we adopted a cost-effectiveness approach (see e.g. Deb et al., 2020; Gonzalez, Valcarcel and Vallejo-Torres, 2020). Cost-effectiveness analysis (CEA) is a method to examine both (social) costs and health effects of one or more policies and measures (Vandepitte et al., 2021). The aim is to combine net costs of given policies and measures with their effects. The resulting cost-effectiveness ratio is useful to compare alternative policies and measures packages (Gift and Marrazzo, 2007) implemented by study cases to cope with the Covid-19 crises. CEA is distinct from cost-benefit analysis (CBA), which assigns a monetary value to policies or measures and related impacts (Bleichrodt and Quiggin, 1999; Phelps and Mushlin, 1991). CEA is often used in the field of health services, where it may be too difficult to monetize health effects[25] (OECD, 2018) generated by a complex mix of public interventions. Typically, the CEA is expressed in terms of gains in health from a policy or measure (e.g. years of life, premature births averted, number of deaths averted) and the cost associated with the health gain (Gold et al., 1996), e.g. GDP loss, job loss, etc.

Understanding the effectiveness of government policy responses in a complex situation such as the ongoing Covid-19 pandemic is not an easy task. The varying impacts observed and the different effects produced by policy responses are the result of a combination of contextual conditions (e.g., population composition, including age and ethnicity, social deprivation, population density, health system status, economic situation, etc.) and national choices in terms of approach in coping the crisis. Indeed, the evolution of economic, social, health or environmental impacts results from a combination of several policies and measures, which should be considered in combination to appreciate and evaluate the effectiveness. Thus, the effectiveness of Covid-19 policy responses has been assessed considering the mix of policies and measures adopted by five countries, namely Denmark, Italy, Israel, Sweden and the United Kingdom, looking at social, economic, health and environmental impacts. These five countries have been chosen by considering the following factors: 1) Different approaches in terms of policy responses to Covid-19 pandemic; 2) Different impacts on socio-economic and health dimensions; 3) Differences in demographics.

Our methodological approach follows incremental phases:

(i) First, we analysed the statistical relationships between policy responses (i.e. containment, economic support and health policies) and socio-economic, health and environmental variables. Statistical relationships (or relationships) exist if a change in one variable X results in a systematic change in another variable Y. In statistical terms, while correlation is a method of assessing a possible two-way association between variables in an exact moment in time (e.g. one quarter), statistical

[25] The concept of cost-effectiveness is widely used in many aspects of life. For instance, in the context of Pharmacoeconomics, the cost-effectiveness of therapeutic or preventive intervention is the ratio between interventions costs and their effectiveness. Cost refers to the resource expended for the intervention, usually measured in monetary terms. The measure of effects depends on the intervention being considered (Bleichrodt and Quiggin, 1999).

relationships assess a possible two-way association between variables over time (e.g. over quarters) (Agresti, 2018). Statistical relationships can be positive (direct) or negative (inverse). Statistical relationships are positive when both variables move in tandem that is, in the same direction. A positive statistical relationship exists when one variable decreases as the other variable decreases, or one variable increases while the other increases. Statistical relationships are negative when one variable's value increases and the other variable's value decreases (and vice versa) (Stock and Watson, 2015). Likewise to correlations, statistical relationships indicate a predictive relationship between two variables, but not causal relationships (Holland, 1986). Indeed, statistical relationship does not imply causation. This refers to the inability to legitimately deduce a cause and effect between two variables solely on the basis of an observed association or relationship between them (Casella and Berger, 2002; Holland, 1986). The goal of statistical relationship is to assess how economic, health and environmental variables have been affected by policy responses over time (2020Q1-2021Q2) in the five study cases. Table 1 reports the sets of statistical relationships that we identified for the five cases studies.

Table 1 Set of statistical relationships performed, 2020Q1 - 2021Q2

| **Categories of statistical relationships** | |
|---|---|
| Statistical relationships between government policy responses (i.e. containment, economic support and health policies) and economic/health/environmental data | Containment policies and socio-economic data |
| | Containment policies and health data |
| | Containment policies and environmental data |
| | Economic support policies and socio-economic data |
| | Economic support policies and health data |
| | Health policies and socio-economic data |
| | Health policies and health data |

Source: GREEN elaboration.

(ii) Relevance of statistical relationships developed in step (i) has been assessed by setting up a matrix of relevance for each study case. According to literature (Dash and Sethi, 2022; Kok, 2020), high relevance implies direct relationships over time between policy responses and economic, health and environmental variables. Relevant statistical relationships identified effective policy responses in reducing economic, health and environmental impacts of the pandemic.

(iii) Results coming from the matrix of relevance allow the identification of different levels of policy efficacy among study cases. This depends on national approaches to implementing policies, especially in terms of policy stringency. National policy models have been identified by assessing study cases' policy stringency. The cost-effectiveness assessment has been carried out per each national model, by attributing monetary values to socioeconomic costs, health and environmental benefits. Two cost factors have been selected for the analysis: national cost for 1. economic support policies, and 2. health policies (buying vaccines, testing measures, contact tracing measures, health-care investments, etc.). Those factors represent direct costs associated with a different implementation of policy responses in the five countries. Three effectiveness factors have been identified for the assessment: 1. GDP recovery, 2. deaths averted through the vaccination campaign, and 3. CO2 emissions reduction. Those factors allow the evaluation of direct effects generated by policies responses, avoiding overlapping counts since the strong interdependence of policies outcomes. For instance, Covid-19 deaths averted by lockdown measures are hard to determine due to the combined presence of several health policies and other containment ones. Cost and effectiveness factors are considered within two years of policy implementation (2020-2021). Following long-term impacts of

policy responses are not considered in this analysis for a lack of data and certain knowledge on the pandemic evolution.

(iv) Finally, cost-effectiveness analyses of national models have been compared.

# 4 Comparative assessment of policy responses and economic, social, health and environmental Covid-19 impacts

Starting from a literature review on assessing policy impacts and effectiveness (Ambrocio, 2022; Bretschger et al., 2020; Deb et al., 2022; Dietrich et al., 2021; Goeb et al., 2022; Hwang, 2021; Konig and Winkler, 2020; Zamfir et al., 2022; Amador et al., 2023; Sharma and Mishra, 2023), we formulate a set of hypotheses concerning the impact of policy responses on socio-economic, health and environmental data.

Hypothesis 1: Stricter containment policies generate negative socio-economic impacts, measured in terms of GDP fall, reduction of import/export and increased job losses.

Hypothesis 2: Stricter containment policies are effective in mitigating pandemic impacts in terms of human health risk, measured in terms of decreasing Covid-19 deaths, Covid-19 cases and positive rate.

Hypothesis 3: Stricter containment policies are effective in producing (temporary) environmental co-benefits in terms of air quality (CO2 emission reduction).

Hypothesis 4: Economic support policies are effective in containing socio-economic impacts generated by containment policies.

Hypothesis 5: Stricter health policies (especially vaccination campaigns) are effective in mitigating impacts on human health, measured in terms of decreasing Covid-19 deaths, Covid-19 cases and positive rate.

Hypothesis 6: Health policies (especially vaccination campaigns) are effective in reducing the need for strict containment policies connected to high socio-economic impacts.

To verify those hypotheses and understand whether and to what extent Covid-19 impact dynamics are influenced by policy responses in the five study cases, we identified a set of statistical relationships[26] between policy responses (i.e. containment, economic support and health policies) and socio-economic, health and environmental variables (Dash and Sethi, 2022; Kok, 2020). Statistical relationships help in figuring out policy effects in terms of reducing economic loss and human risks and generating co-benefits. The analyses aim also to identify differences among countries in terms of policy efficacy. The statistical relationship performed are listed in Table 2.

Table 2 List of statistical relationships between policy responses and socio-economic, health, environmental variables

| **Statistical relationships** | | | |
|---|---|---|---|
| | **Socio-economic dimension** | **Health dimension** | **Environmental dimension** |

[26]Statistical relationships are defined as any two-way association or relationship between variables, i.e. the degree to which these variables are related over time (Agresti, 2018). Some studies name comparative assessments between Covid-19 policy responses and socio-economic, health and environmental variables with the term "correlations" if they refer to an exact moment in time (see Yeyati and Filippini, 2021), or "evolution" (see Boone and Ladreit, 2021).

| | | | |
|---|---|---|---|
| **Containment policies** | Stringency index and GDP | Stringency index and Covid-19 deaths | Stringency index and CO2 emissions |
| | Stringency index and exports | Stringency index and Covid-19 cases | |
| | Stringency index and imports | Stringency index and positive rate | |
| | Stringency index and unemployment rate | | |
| | Stringency index and youth unemployment rate | | |
| | | | |
| **Economic support policies** | Debt relief and GDP | | |
| | Debt relief and exports | | |
| | Debt relief and imports | | |
| | Debt relief and unemployment rate | | |
| | Debt relief and youth unemployment rate | | |
| | Income support and GDP | | |
| | Income support and exports | | |
| | Income support and imports | | |
| | Income support and unemployment rate | | |
| | Income support and youth unemployment rate | | |
| | | | |
| **Health policies** | Face coverings and GDP | Face coverings and Covid-19 deaths | |
| | Face coverings and exports | Face coverings and Covid-19 cases | |
| | Face coverings and imports | Face coverings and positive rate | |
| | Face coverings and unemployment rate | Testing and Covid-19 deaths | |
| | Face coverings and youth unemployment rate | Testing and Covid-19 cases | |
| | Testing and GDP | Testing and positive rate | |
| | Testing and exports | Contact tracing and Covid-19 cases | |
| | Testing and imports | Contact tracing and positive rate | |
| | Testing and unemployment rate | Vaccination measure and Covid-19 deaths | |
| | Testing and youth unemployment rate | | |
| | Contact tracing and GDP | | |
| | Contact tracing and exports | | |
| | Contact tracing and imports | | |
| | Contact tracing and unemployment rate | | |
| | Contact tracing and youth unemployment rate | | |

| | | | |
|---|---|---|---|
| | Vaccination measure and GDP | | |
| | Vaccination measure and exports | | |
| | Vaccination measure and imports | | |
| | Vaccination measure and unemployment rate | | |
| | Vaccination measure and youth unemployment rate | | |

Source: GREEN elaboration.

The Stringency index is a composite measure of nine response metrics, i.e. school closures, workplace closures, cancellation of public events, restrictions on public gatherings, cancellation of public transport, public information campaigns, restrictions on internal movement, restrictions on international travel, stay at home requirements (Hale et al., 2021). Debt relief captures if the government is freezing financial obligations during the Covid-19 pandemic such as stopping loan repayments, preventing services like water from stopping, and banning evictions. Income support captures if the government is covering the salaries or providing direct cash payments, universal basic income, or similar, for people who lose jobs or cannot work. Face coverings regard the mandatory use of face masks. It is expressed by looking at the strictness level of implementation, between no face masks requirements, required in some specified shared/public spaces, required in all shared/public spaces. Testing measures are investigated by looking at target users: only for those who both have symptoms and meet specific criteria (e.g. key workers, admitted to hospital, came into contact with a known case, returned from overseas), anyone showing symptoms, everyone even without symptoms. Contact tracing is a complementary health measure, in addition to the testing one. Contact tracing is expressed by looking at the target and frequency of measure implementation: not in all cases, and in all cases. Vaccination expresses the total amount of fully vaccinated people. A person is considered fully vaccinated 14 days after receiving the second dose of Covid-19 vaccine[27].

Data on policy responses evolution, stringency and intensity come from a combination of two sources: Oxford Covid-19 Government Response Tracker Database (Hale et al, 2021) and an in-depth analysis of each case study.

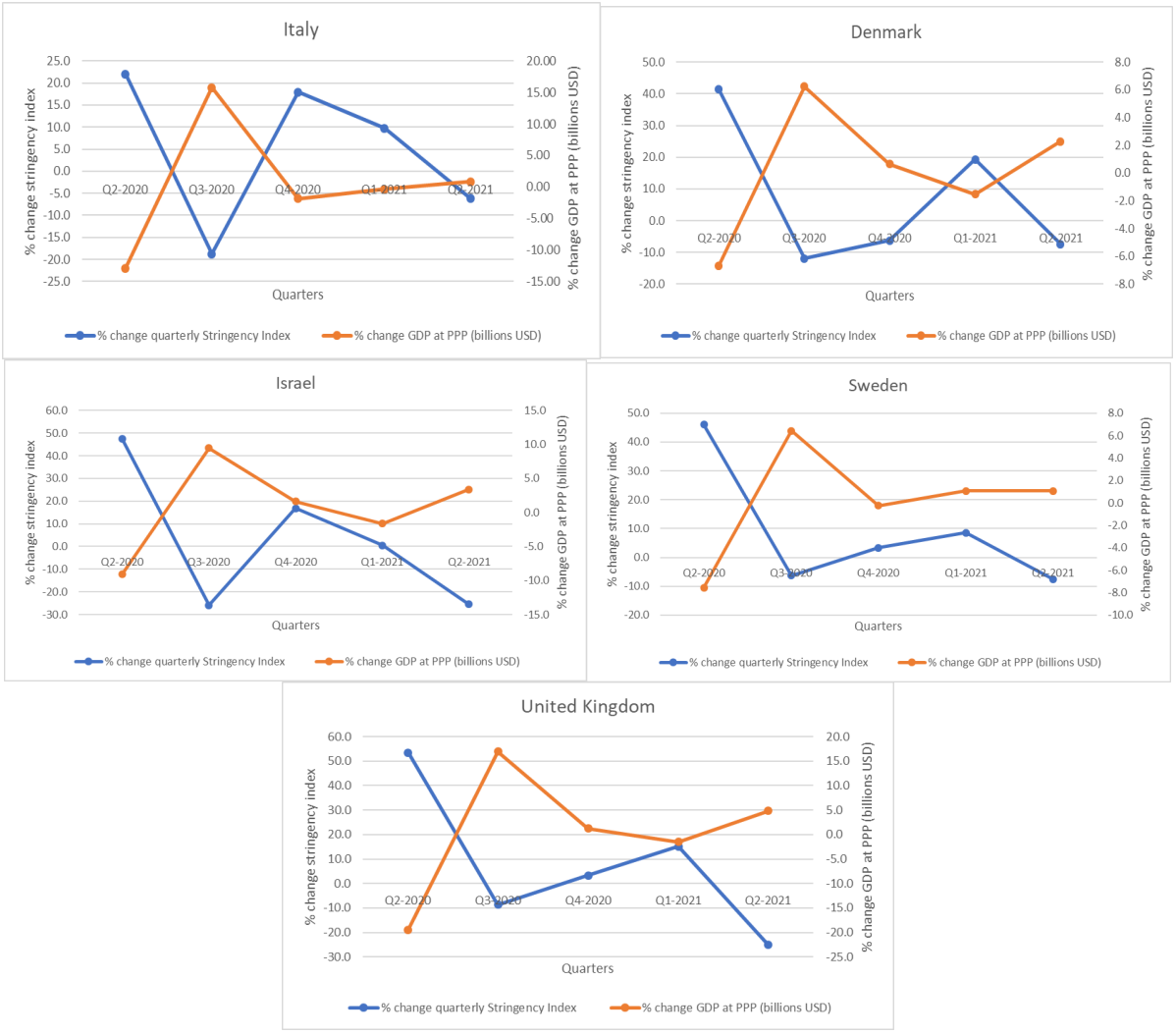
## 4.1 Statistical relationships between containment policies and socio-economic, health and environmental data

### 4.1.1 Statistical relationship between stringency index and GDP

All countries report an inverse (negative) statistical relationship between stringency index and GDP from spring 2020 to the second quarter of 2021. This suggests that when the stringency index increases, GDP decreases.

[27] https://www.cdc.gov/coronavirus/2019-ncov/vaccines/stay-up-to-date.html

Figure 1 Statistical relationship between stringency index and GDP at PPP (% Q/Q), 2020Q2 - 2021Q2



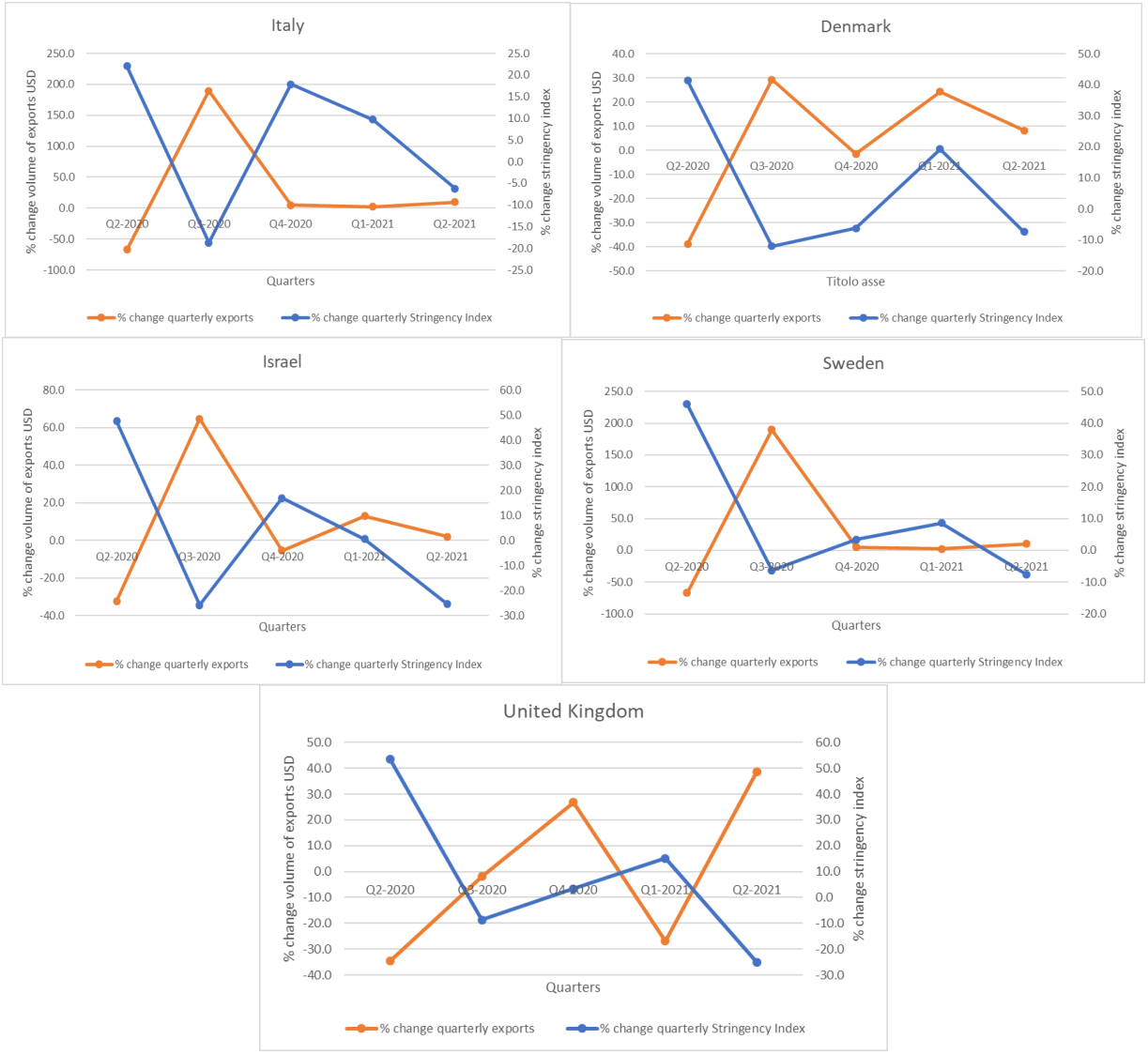

Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and OECD Dataset.

Results in Figure 1 are in line with many studies (see e.g. Demirguc-Kunt et al., 2020; Egert et al., 2020; IMF, 2020) showing that stricter lockdowns are associated with more important falls in economic activities. Indeed, the inverse statistical relationship between stringency index and GDP in Figure 18 is extremely significant during the first wave of the pandemic and immediately after, when their opposite variations were stronger. The GDP loss increased in quarters when containment policies become stricter, representing the social cost of these policies that entail – among others – closures of workplaces and of public transport, travel restrictions and so on. Conversely, the GDP recovery occurred in summer 2020 comes from the effect of containment policies lifting, which allowed economic and social activities to restart.

### 4.1.2 Statistical relationship between stringency index and exports

All countries – with the partial exception of Denmark - show an inverse (negative) statistical relationship between the stringency index and exports from spring 2020 to spring 2021. When the stringency index increases, exports of goods and services decrease.

Figure 2 Statistical relationship between stringency index and exports (%Q/Q), 2020Q2 - 2021Q2




Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and OECD Dataset.

Figure 2 shows that stricter containment policies – measured by a higher stringency index - translate into a stop or reduction of trade activities (decreasing exports) and vice versa. Hayakawa and Mukunoki (2021) find that the fall of exports that follows stricter containment policies is the possible aftermath of the implementation of containment policies. We should also consider a lag effect in our analysis, especially in the case of Denmark which adopted less strict containment policies during the period analysed which did not cause a complete stop of trade activities. In this case, a low decrease in exports occurs after the adoption of stricter containment policies.

### 4.1.3 Statistical relationship between stringency index and imports

All countries – with the partial exception of Denmark and Israel - show a negative (inverse) statistical relationship between stringency index and imports during the whole period under investigation. This reveals that a reduction of the stringency index is accompanied by an increase in imports.

Figure 3 Statistical relationship between stringency index and imports (% Q/Q), 2020Q2 - 2021Q2

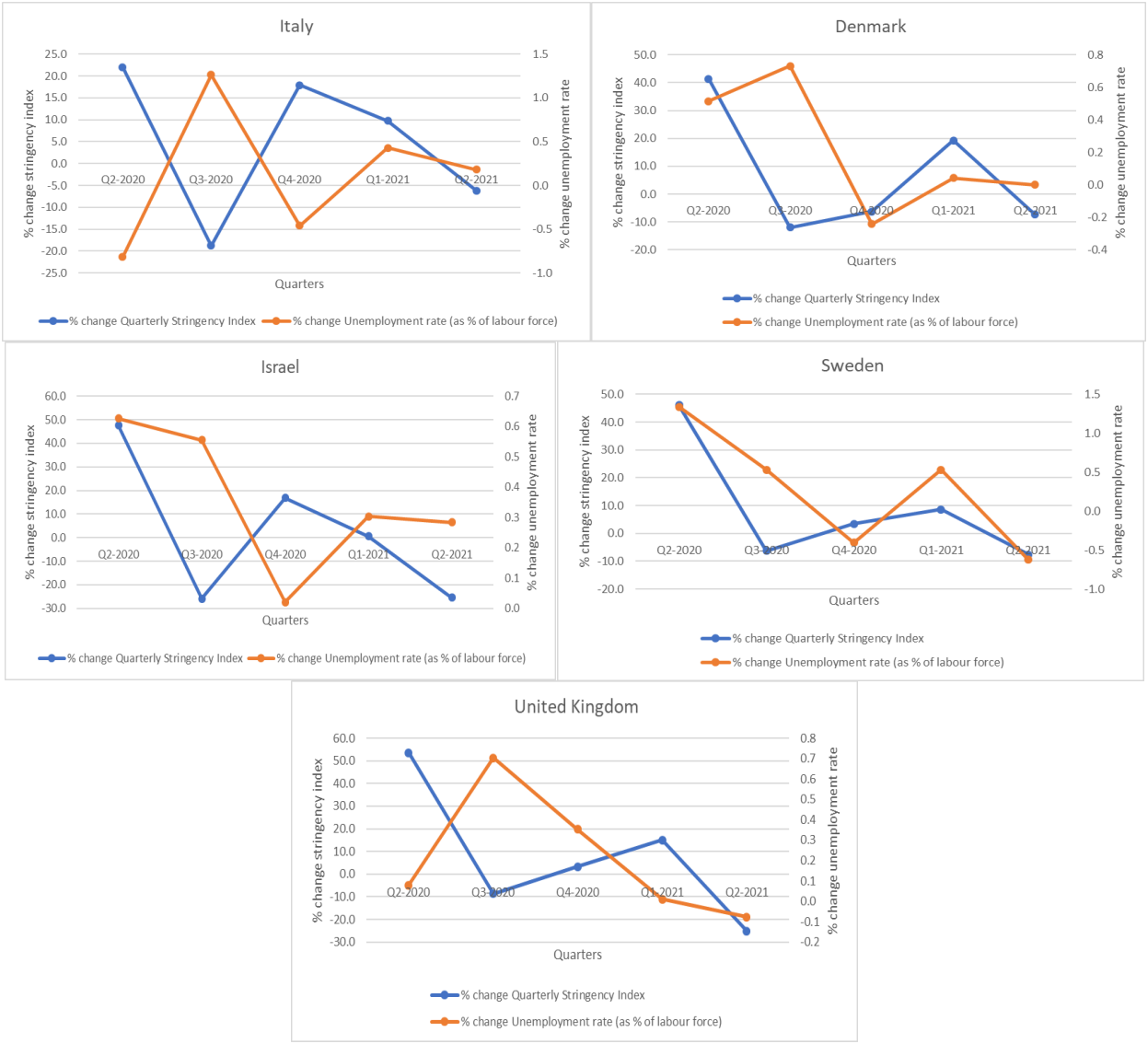

Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and OECD Dataset.

Figure 3 shows inverse statistical relationship, revealing that stricter containment policies – represented by a higher stringency index - are associated with a reduction in imports. Thus, interruptions of trade (import) activities may occur even after the introduction of less strict lockdown measures, as in Denmark and Israel from early 2021 onwards.

### 4.1.4 Statistical relationship between stringency index and unemployment rate

The statistical relationship between the stringency index and the unemployment rate is negative (inverse) in all countries from the second quarter of 2020 to spring 2021, with the partial exception of Denmark and Sweden. This means that the unemployment rate decreases when the stringency index increases. Denmark reports a negative (inverse) statistical relationship from the second to the fourth quarter of 2020, and a positive (direct) statistical relationship between the first and second quarter of 2021. Sweden reports a positive (direct) statistical relationship between stringency index and the unemployment rate, i.e. when the stringency index decreases unemployment rate also decreases in the same quarter.

Figure 4 Statistical relationship between stringency index and unemployment rate (% Q/Q), 2020Q2 - 2021Q2




Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and OECD Dataset.

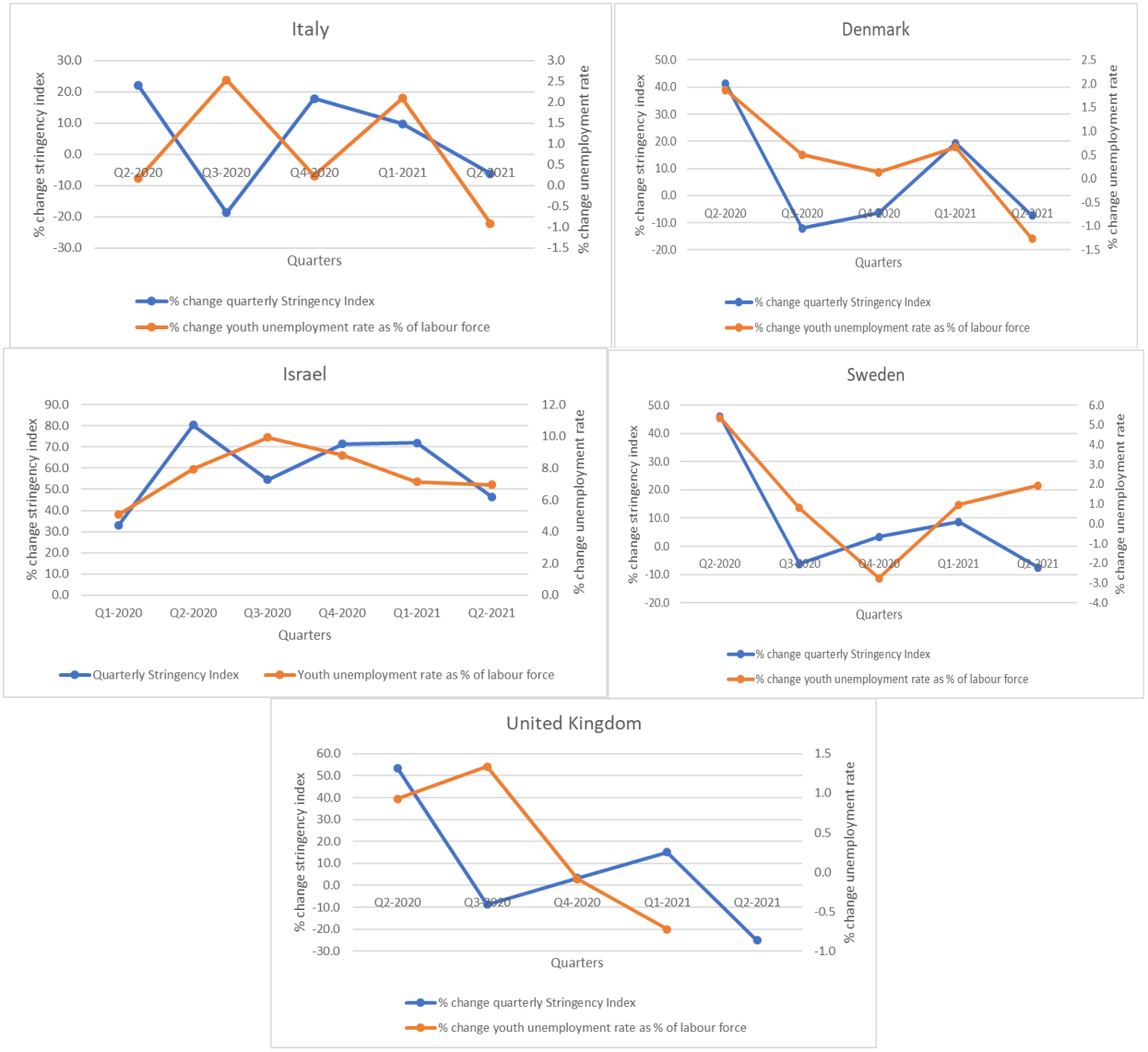
Figure 4 shows that containment policies may have no direct impact on the labour market. Direct effects occurred only in a few countries. Moreover, this relationship changes during the period analysed, especially in Denmark and Sweden. This may be related to the introduction of economic support policies, like layoff limitation measures, which reduce the negative effects of containment ones.

### 4.1.5 Statistical relationship between stringency index and youth unemployment rate

The statistical relationship between stringency index and the youth unemployment rate is negative (inverse) in all countries (except for Denmark), i.e. when the stringency index decreases youth unemployment rate increases. Denmark has a positive (direct) statistical relationship between stringency index and youth unemployment rate from spring 2020 to the second quarter of 2021,

revealing that a decrease of stringency index is accompanied by a decrease of the youth unemployment rate.

Figure 5 Statistical relationship between stringency index and youth unemployment rate (% Q/Q), 2020Q2 - 2021Q2




Note: data on youth unemployment rate are not available for the second quarter of 2021.

Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and OECD Dataset.

Figure 5 shows that containment policies do not have a strong impact on youth unemployment rate, considering the negative (inverse) statistical relationship between stringency index and youth unemployment rate. These statistical relationships must be positive in order to be significant because stricter containment policies should translate into an increasing youth unemployment rate and vice versa, as in the case of Denmark.

### 4.1.6 Statistical relationship between stringency index and Covid-19 deaths

The majority of countries reports positive (direct) statistical relationships between stringency index and Covid-19 deaths, although with some exceptions. This suggests that a decrease in the stringency index is due to a decrease in Covid-19 deaths. Italy and Denmark show a positive (direct) statistical relationship between stringency index and Covid-19 deaths during the whole period under study, i.e. from spring 2020 to spring 2021. This suggests a high efficacy of containment policies in reducing deaths. Israel, Sweden and the United Kingdom show both positive (direct) and negative (inverse) statistical relationships from the second quarter of 2020 to spring 2021. Negative (inverse) statistical relationships take place when the stringency index increases and Covid-19 deaths decrease. This indicates a precautional approach adopted by those countries, which decided to intensify restrictions to avoid further crises.

Figure 6 Statistical relationship between stringency index and number of Covid-19 deaths (% Q/Q), 2020Q2 - 2021Q2

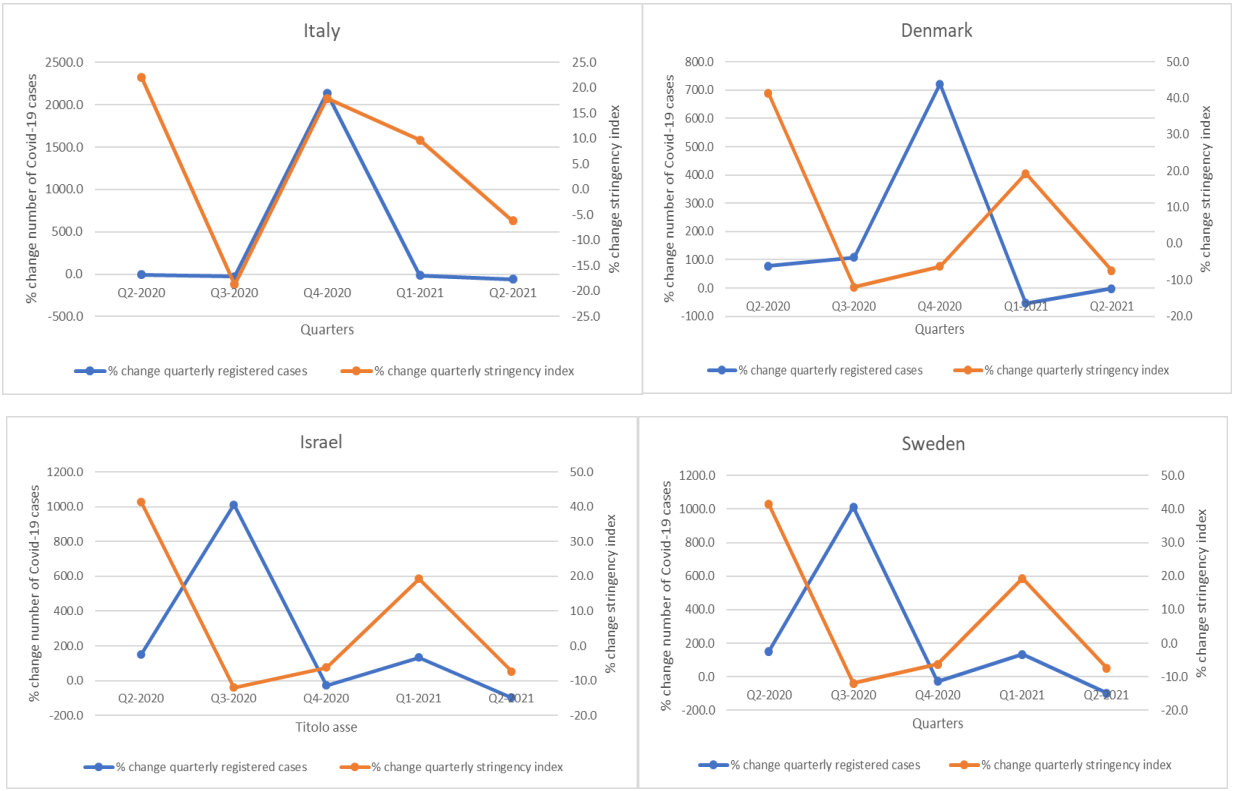

Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and World Health Organization Dataset.

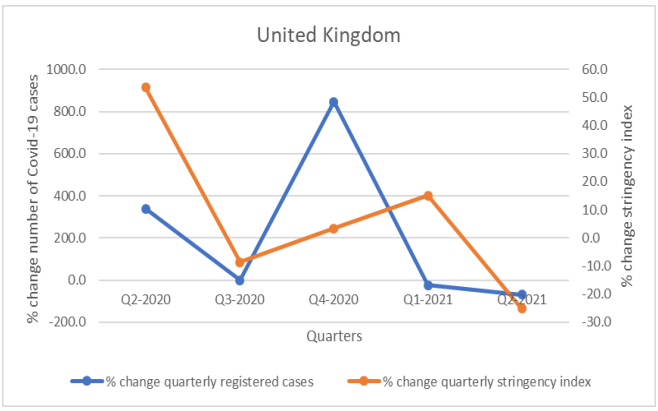
Figure 6 reports results in line with the findings of Conyon et al. (2020) who show that stricter containment policies are associated with a reduction in Covid-19 related deaths. We also consider a temporal lag in our analysis because Covid-19 deaths may reduce after the implementation of stricter containment policies. In fact, - especially in Italy and Denmark - when the stringency index augments in a quarter, the following quarter is characterized by decreasing Covid-19 deaths. We assume that it may often take time for containment policies to have a substantial impact on Covid-19 deaths variation.

### 4.1.7 Statistical relationship between stringency index and Covid-19 cases

The five country cases show heterogeneous results concerning statistical relationships between containment policies and Covid-19 cases. Italy and the United Kingdom report an inverse statistical relationship between stringency index and Covid-19 cases with a lag effect, i.e. when stringency index decreases Covid-19 cases increase in the following quarter. Denmark and Sweden also report an inverse statistical relationship between stringency index and Covid-19 cases, but in the same quarter and vice versa. Israel has a mix of positive (direct) and negative (inverse) statistical relationships between stringency index and Covid-19 cases. Precisely, Israel has a negative (inverse) statistical relationship between the second and last quarter of 2020, and a positive (direct) statistical relationship from the end of 2020 to spring 2021.

Figure 7 Statistical relationship between stringency index and number of Covid-19 cases (% Q/Q), 2020Q2 - 2021Q2





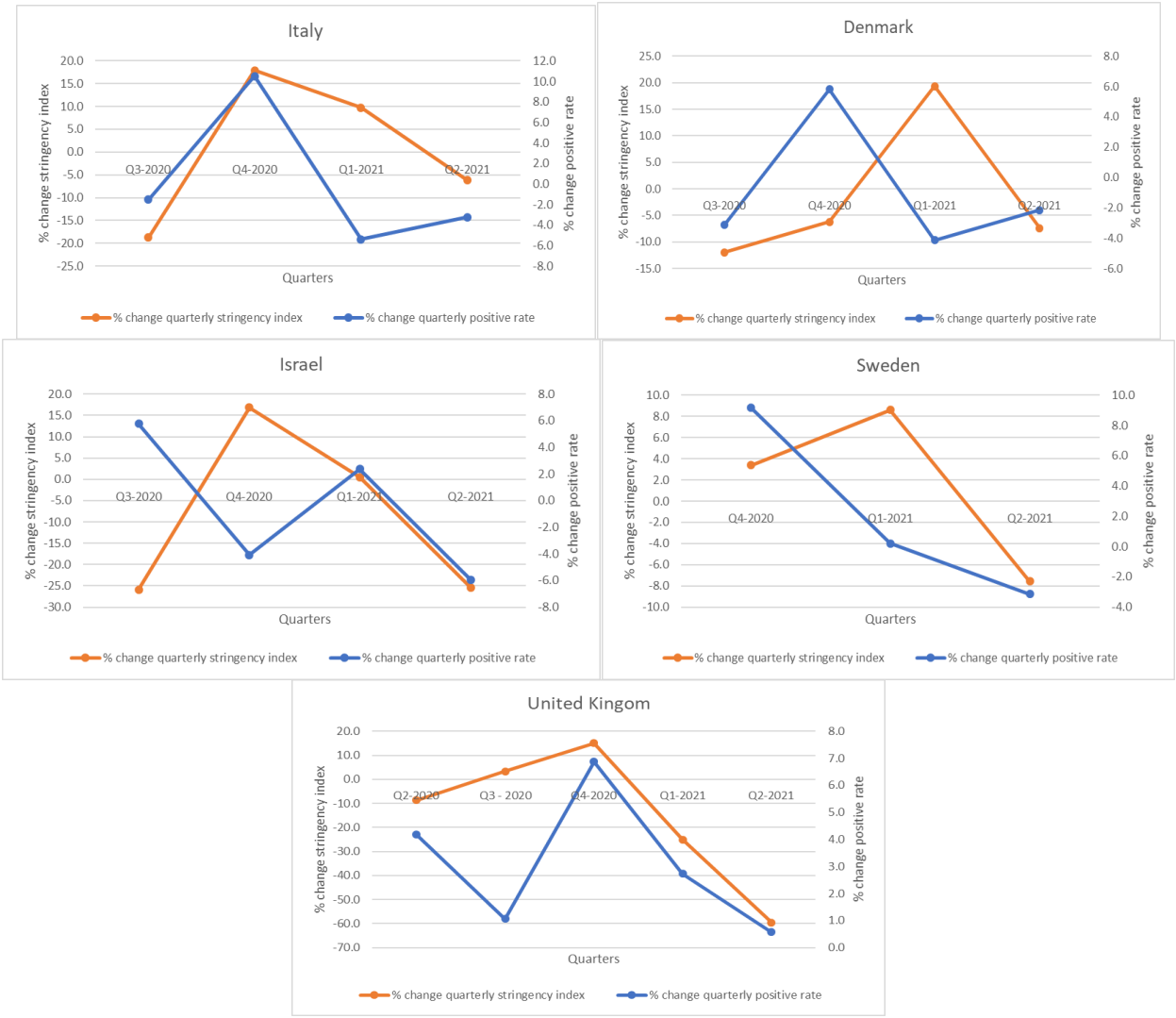

Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and World Health Organization Dataset.

Countries show direct statistical relationship between stringency index and Covid-19 cases but with different lag effects. Indeed, when containment policies become stricter – with an increasing stringency index – Covid-19 cases decrease immediately (Denmark and Sweden) or with a longer lag effect (Italy and the UK). This demonstrates that lockdown measures had a positive impact in containing Covid-19 cases (Kharroubi and Saleh, 2020). Specifically, Denmark has moderate Covid-19 infection numbers on average that have been accompanied by soft, but relatively successful lockdown measures (Andersen et al., 2020). In countries most hit by the pandemic, Italy and the UK, the level of strictness of containment policies is associated with a high spread of Covid-19 cases. When Covid-19 cases high increase, governments intensify restrictions, which need time to produce effective effects. Conversely in Denmark, Israel and Sweden shorter and less strict restrictions can produce effects more quickly.

### 4.1.8 Statistical relationship between stringency index and positive rate

The five countries report different results on statistical relationships between containment policies and positive rate. Italy, Sweden and the United Kingdom report a positive (direct) statistical relationship between stringency index and positive rate, i.e. when stringency index increases, positive rate increases. Denmark has a negative (inverse) statistical relationship between stringency index and positive rate, revealing that an increase of stringency index is accompanied by a decrease of positive rate. Israel reports an inverse (negative) statistical relationship between stringency index and positive rate from summer 2020 to the first quarter of 2021 and a positive (direct) statistical relationship after early 2021.

Figure 8 Statistical relationship between stringency index and positive rate (% Q/Q), 2020Q2 - 2021Q2



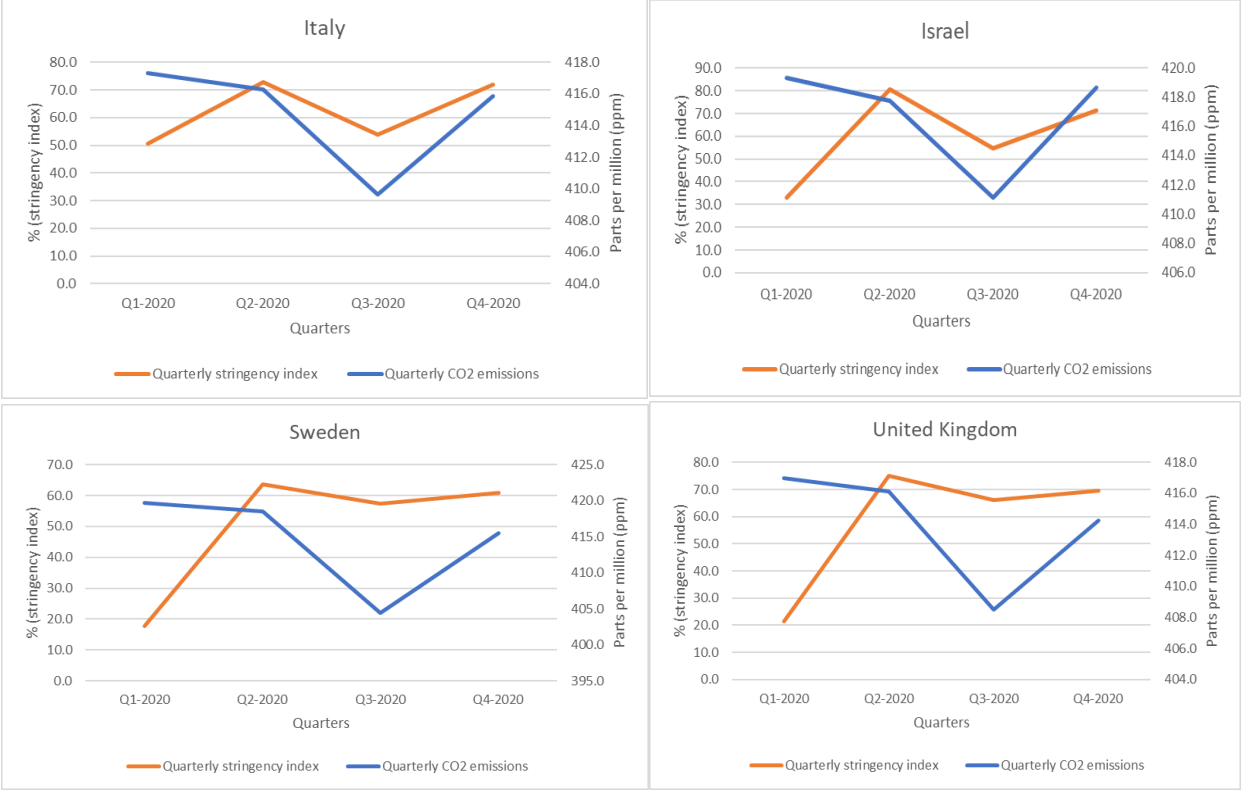

Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and World Health Organization Dataset.

Figure 8 shows that there is no direct statistical relationship between containment policies and Covid-19 positive rate. The positive rate shows the percentage of all Covid-19 tests performed by a country that are actually positive. When Covid-19 cases increase, testing performed daily increases as well. Containment policies may have an impact on reducing Covid-19 infections but not in reducing the positive rate, which is a proxy to evaluate the efficacy of testing and contact tracing measures. Conversely, we identify an inverse statistical relationship between positive rate and stringency index in the case of Denmark, for which the statistical relationship is significant. Indeed, stricter containment policies adopted in a quarter – with an increasing stringency index – have reduced Covid-19 positive rates the same quarter. This might be due to the low spread of Covid-19 infection among the Denmark population, considering the low density.

### 4.1.9 Statistical relationships between stringency index and environmental data

All countries show negative (inverse) statistical relationships between stringency index and CO2 emissions, i.e. an increase of stringency index translates into a decrease of CO2 emissions. Precisely, Italy, Sweden, Israel and the United Kingdom have negative (inverse) statistical relationships between early 2020 and spring 2020, when lockdown measures were stricter.

Figure 9 Statistical relationship between stringency index and CO2 emissions, 2020Q1 - 2020Q4




Note: data on CO2 emissions are not available for Denmark.

Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and World Health Organization Dataset.

Analysing Figure 9, we identify direct statistical relationship between containment policies and air quality in all countries. The reduction of CO2 emissions is generated by the interruptions of industrial/commercial activities and massive traffic reductions related to lockdowns. Conversely, when containment policies are lifted in a quarter CO2 emissions restart augmenting in the following quarter. Indeed, a reduction of CO2 emissions can occur after the adoption of stricter containment policies (Menut et al., 2020).

### 4.1.10 Synthesis of statistical relationships between containment policies and socio-economic, health and environmental data

We identify direct statistical relationships between quarterly variations of containment policies (measured by the stringency index) and socio-economic variables in all countries, especially between stringency index and GDP. When stringency index becomes higher, GDP decreases. Conversely, when containment policies are lifted, GDP increases. This is in line with many studies (see e.g. Demirguc-Kunt et al., 2020; Egert et al., 2020; IMF, 2020) showing that stricter lockdowns are

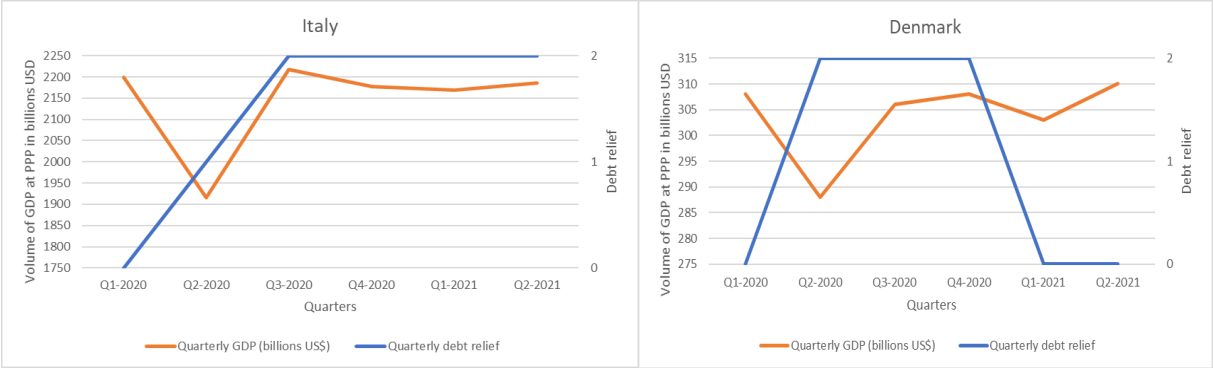
associated with more important falls in economic activities. Containment policies do not show a direct relationship with unemployment rate in all countries, with the exception of Sweden. However, we noticed that less strict lockdown measures bring a low decrease in unemployment rate, i.e. reduced job losses. Reduced job losses represent a reduction of social costs due to the lifting of containment policies (Auray and Eyquem, 2020). Unemployment rate might be most affected by economic support policies than containment ones. Statistical relationships between containment policies and health variables are relevant in all countries. When containment policies become stricter, there is a positive impact on human health, especially in terms of reduced Covid-19 deaths. Conversely, when containment policies are lifted (e.g. in summer 2020) – with decreasing stringency index – Covid-19 deaths and Covid-19 cases restart increasing, given the restart of social interactions. The statistical relationships between containment policies and environmental variables (i.e. CO2 emissions) show direct relationships. Stricter containment policies are accompanied by a reduction of CO2 emissions. Interruptions/reductions of economic and industrial activities due to stricter lockdown measures may have generated a reduction of air pollution, measured in terms of CO2 emissions[28]. This trade-off is identified particularly during the first wave of Covid-19 pandemic when lockdowns were harsher and more generalized (Schneider et al., 2022).

## 4.2 Statistical relationships between economic support policies and socio-economic data

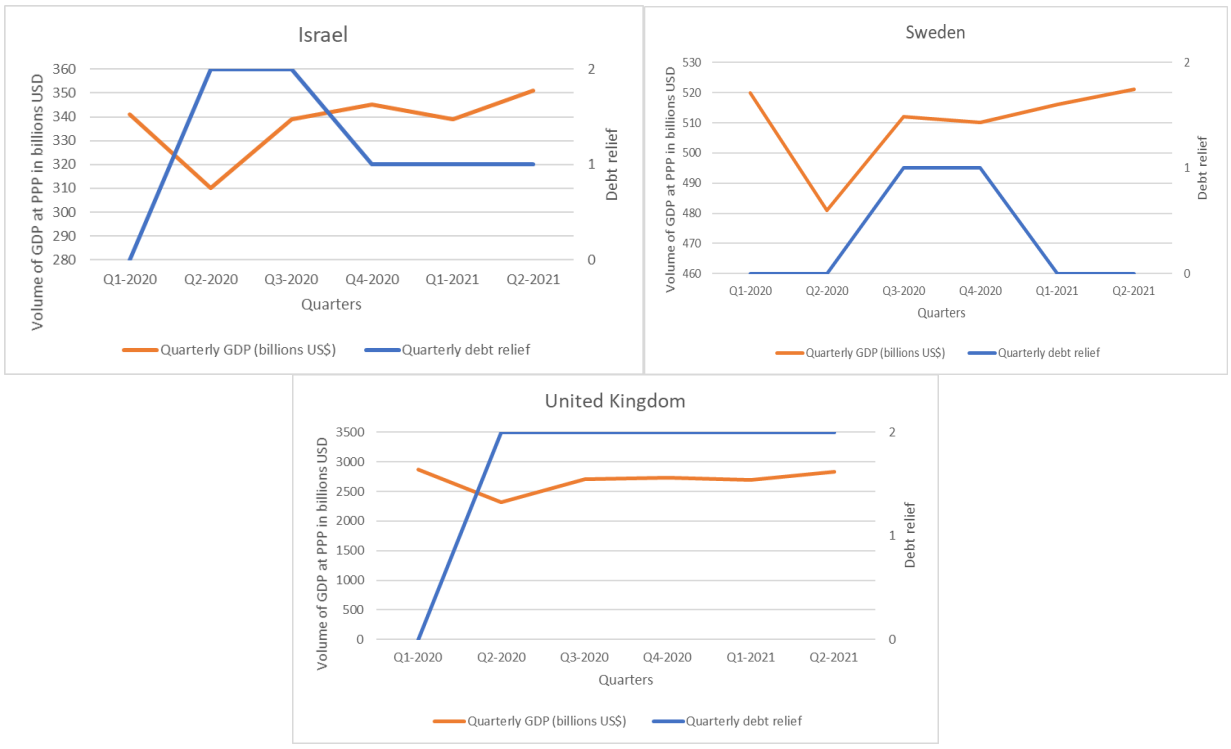
### 4.2.1 Statistical relationship between debt relief and GDP

The majority of countries report a positive effect of debt relief measures. Debt relief captures if the government is freezing financial obligations during the Covid-19 pandemic such as stopping loan repayments, preventing services like water from stopping, and banning evictions. When strong economic policies are set up, GDP increase in the following quarter.

Figure 10 Statistical relationship between debt relief and GDP at PPP, 2020Q1 - 2021Q2




[28] https://news.un.org/en/story/2021/09/1099092



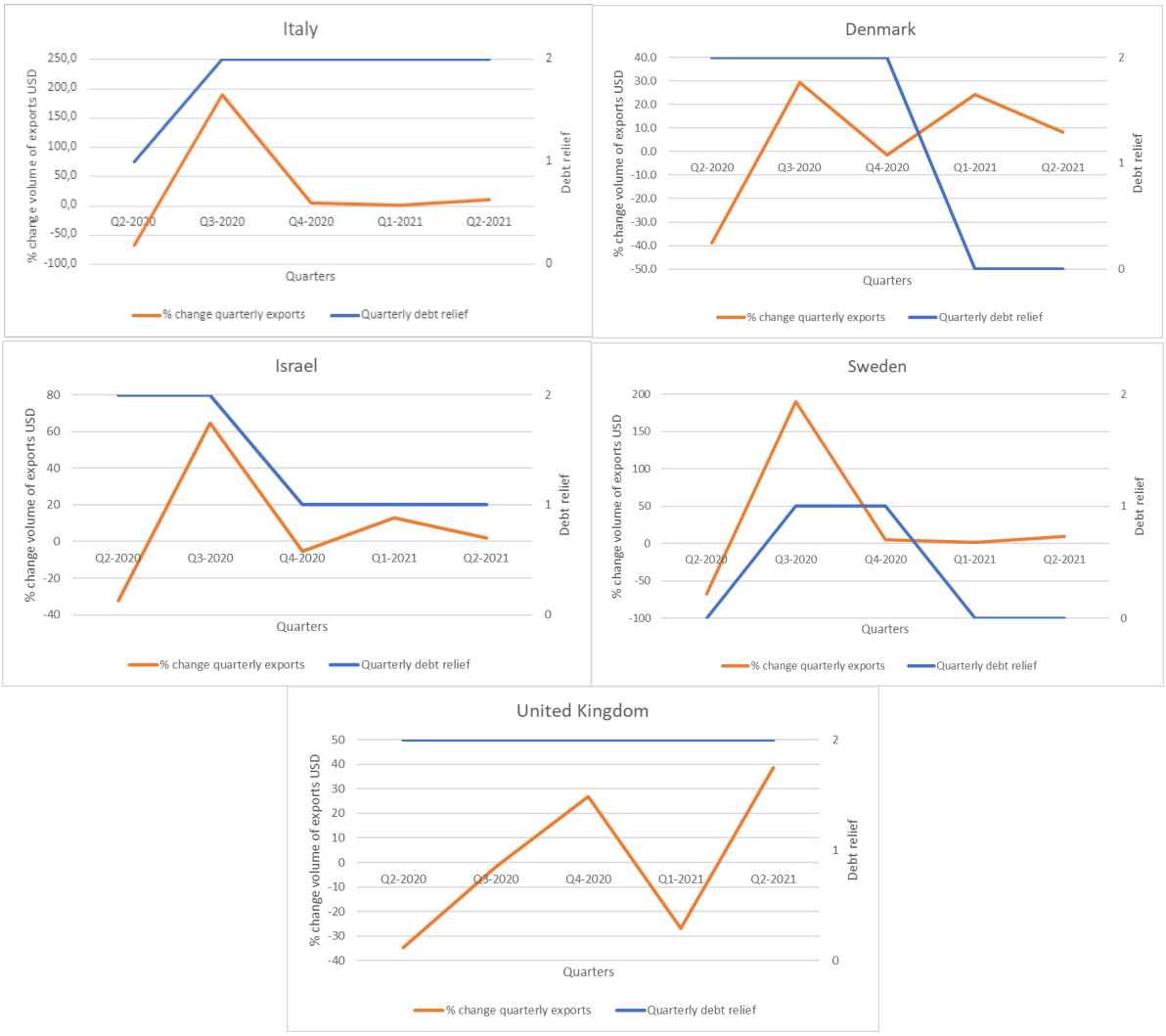

Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and OECD Dataset.

Figure 10 shows that economic support policies to companies have a positive impact and show direct statistical relationship with economic activities in Denmark and the United Kingdom. In Denmark and the United Kingdom, debt relief measures seem to be effective in mitigating the social costs of containment policies undertaken at the national level. This suggests that economic support policies (e.g. debt relief targeted to companies) should be implemented jointly with containment policies, in order to compensate the related social costs (see e.g. Witteveen, 2020 for evidence on the United Kingdom on this).

### 4.2.2 Statistical relationship between debt relief and exports

The five countries show mixed statistical relationship results between debt relief and exports. Italy, Denmark and Sweden report an inverse statistical relationship between debt relief and exports. Here a higher level of debt relief is followed by a decreasing trend of exports. Israel shows a positive (direct) statistical relationship between spring 2020 and the second quarter of 2021, revealing that decreasing debt relief measures are accompanied by decreasing shares of exports. The statistical relationship between debt relief and exports in the United Kingdom is neither positive nor negative, because the adoption of maximum level of debt relief between spring 2020 and spring 2021 is accompanied by variations of exports that are unrelated to debt relief economic measures.

Figure 11 Statistical relationship between debt relief and exports of goods and services, 2020Q2 - 2021Q2




Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and OECD Dataset.

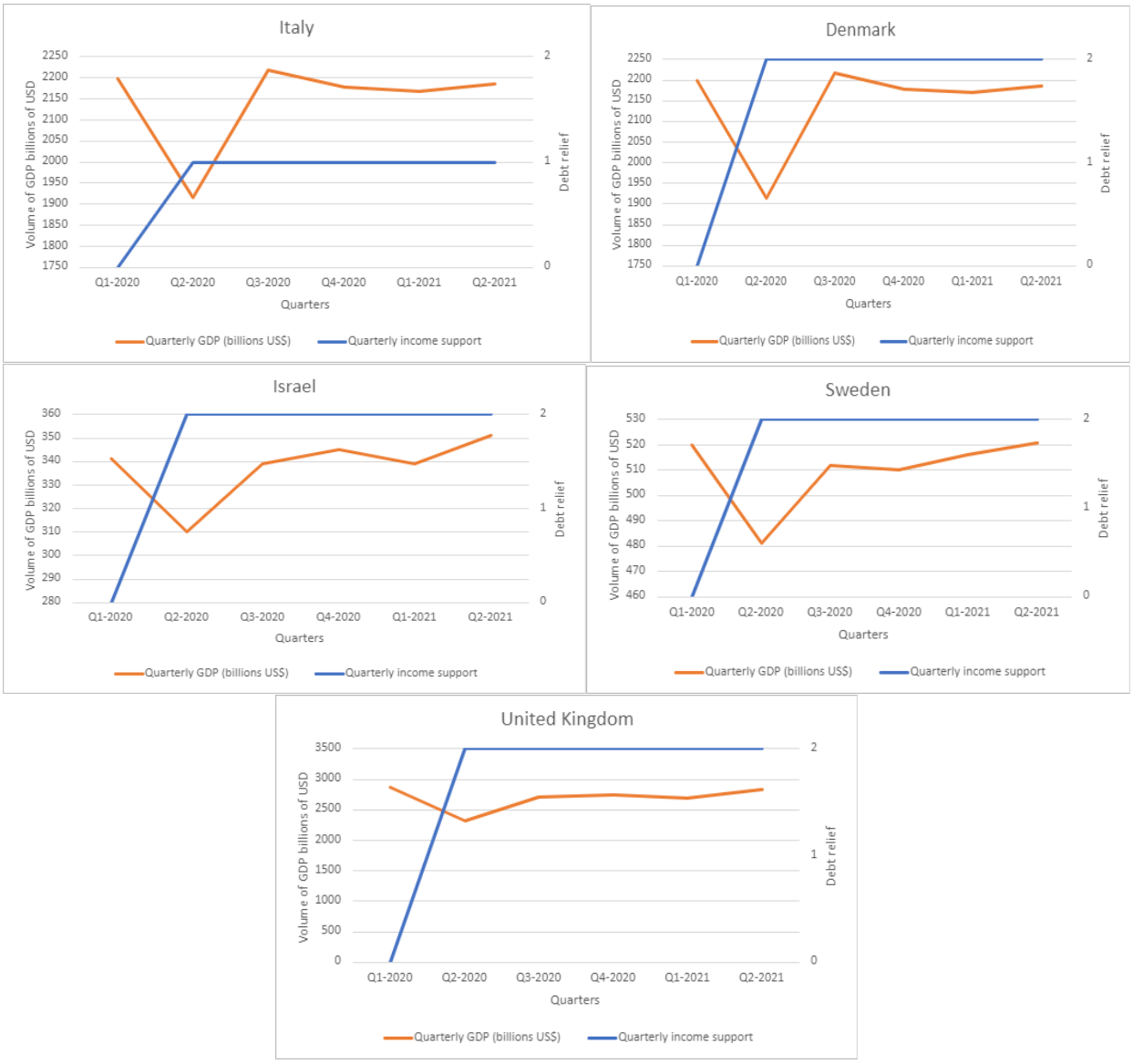
Figure 11 shows that Israel is the only country showing direct statistical relationship between economic support policies to companies and exports variations. This means that stronger debt relief measures - adopted by the Israeli government to support enterprises during Covid-19 pandemic – show effectiveness in increasing trade activities (i.e. exportation of goods and services), as also confirmed by Birenbaum-Carmeli and Chassida (2021). Other countries' results can be affected by the mixed presence of other policies which reduce the effectiveness of debt relief measures.

### 4.2.3 Statistical relationship between income support and GDP

The majority of countries shows positive (direct) statistical relationships between income support and GDP, i.e. an increasing income support is accompanied by an increasing GDP from spring 2020 onwards. Specifically, Israel, Sweden and the United Kingdom show positive (direct) statistical relationships between income support and GDP. Italy and Denmark report an inverse (negative) statistical relationship between income support and GDP from the first quarter of 2020 to the second

quarter of 2021, i.e. an increasing income support is accompanied by decreasing GDP. This can be related to lower support measures in Italy compared to other countries, and side-effects generated by a worsened Covid-19 wave in Denmark in the second quarter of 2020.

Figure 12 Statistical relationship between income support and GDP at PPP, 2020Q1 - 2021Q2



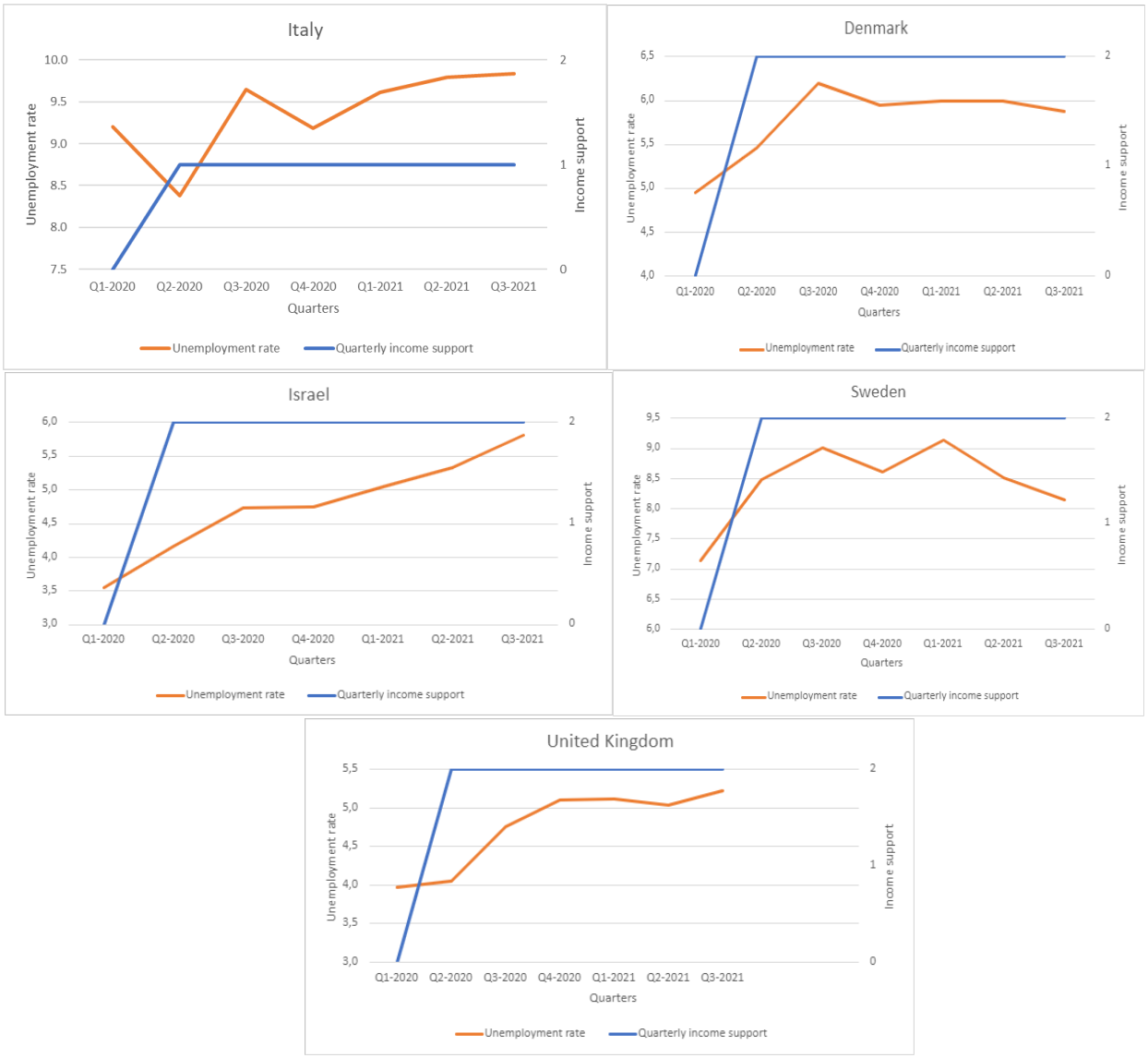

Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and OECD Dataset.

Figure 12 shows that an increasing level of income support to family – covering more than 50% of lost salary – has a positive impact on countries' GDP. Thus, we consider the positive (direct) statistical relationships between income support and GDP as significant in stimulating these economies and in reducing the social costs of containment policies. Indeed, containment policies generate higher GDP losses if not accompanied by strong economic support policies that mitigate the negative impact of Covid-19 pandemic (Pianta, 2021).

### 4.2.4 Statistical relationship between income support and unemployment rate

The five country cases show mixed results from the statistical relationship analysis between income support and unemployment rate. Italy and Sweden do not report any statistical relationship between income support (targeted to households). Denmark and the United Kingdom show a negative (inverse) statistical relationship between income support and unemployment rate, considering that the maximum level of income support (covering more than 50% of lost salary) is accompanied by declining unemployment rate from summer 2020 to summer 2021. Israel has a positive (direct) statistical relationship between income support and unemployment rate, considering that strengthening income support measures are followed by an increasing unemployment rate between the second quarter of 2020 and summer 2021.

Figure 13 Statistical relationship between income support and unemployment rate, 2020Q1 - 2021Q3




Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and OECD Dataset.

Economic support measures to family incomes do not show significant impact on labour market, considering that unemployment rate variations between early 2020 and summer 2021 are not affected

by income support measures. Denmark and the United Kingdom represent a relevant exception to this trend. Indeed, the UK and the Danish governments' labour markets and income support to Covid-19 pandemic was principally focused on maintaining workers' attachment to their employment using a wage subsidy scheme (Fletcher, 2020).

### 4.2.5 Synthesis of statistical relationships between economic support policies and socio-economic data

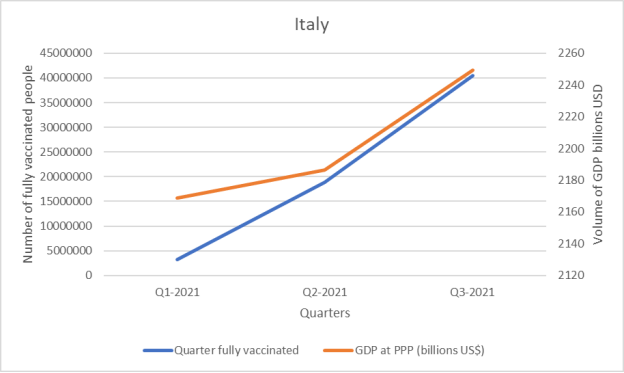
The statistical relationships between economic support policies and socio-economic data partially show direct relationships. Debt relief measures – i.e. economic support to companies – report direct relationship with GDP variations in Denmark and the United Kingdom. Indeed, stronger economic support policies aimed at relieving companies' debts during Covid-19 pandemic are accompanied by a GDP recovery. In Denmark, and especially the United Kingdom, debt relief measures seem to have positively contributed to mitigate the social costs (GDP losses) generated by containment policies. This suggests that economic support policies (e.g. debt relief targeted to companies) should be implemented jointly with containment policies, in order to compensate the related social costs (see Witteveen, 2020). Less direct relationship emerged between economic support policies targeted at companies and trade data, with the partial exception of Israel. Regarding statistical relationships between income support measures targeted at family incomes and socio-economic variables, we find direct relationship, with GDP variations in the majority of countries, especially Israel and the United Kingdom. An increasing level of income support to family incomes – covering more than 50% of lost salary – is linked to increasing levels of GDP. Thus, it seems that broader income support helps stimulating the recovery of these economies, by reducing the social costs (i.e. GDP losses) of containment policies. Additionally, family income support measures also have direct linkages with unemployment rate in Denmark and the United Kingdom, considering that an increase of income support is accompanied by decreasing unemployment rates in those two countries.

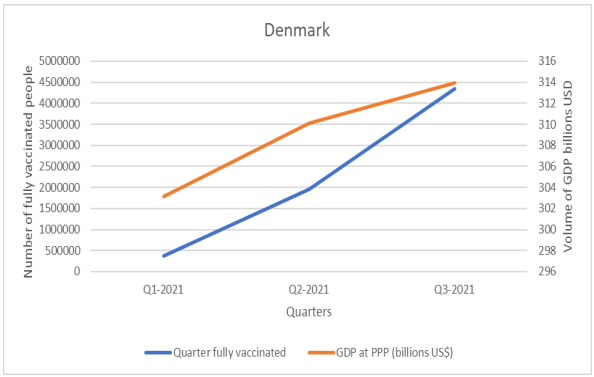
## 4.3 Statistical relationships between health policies and socio-economic, health data

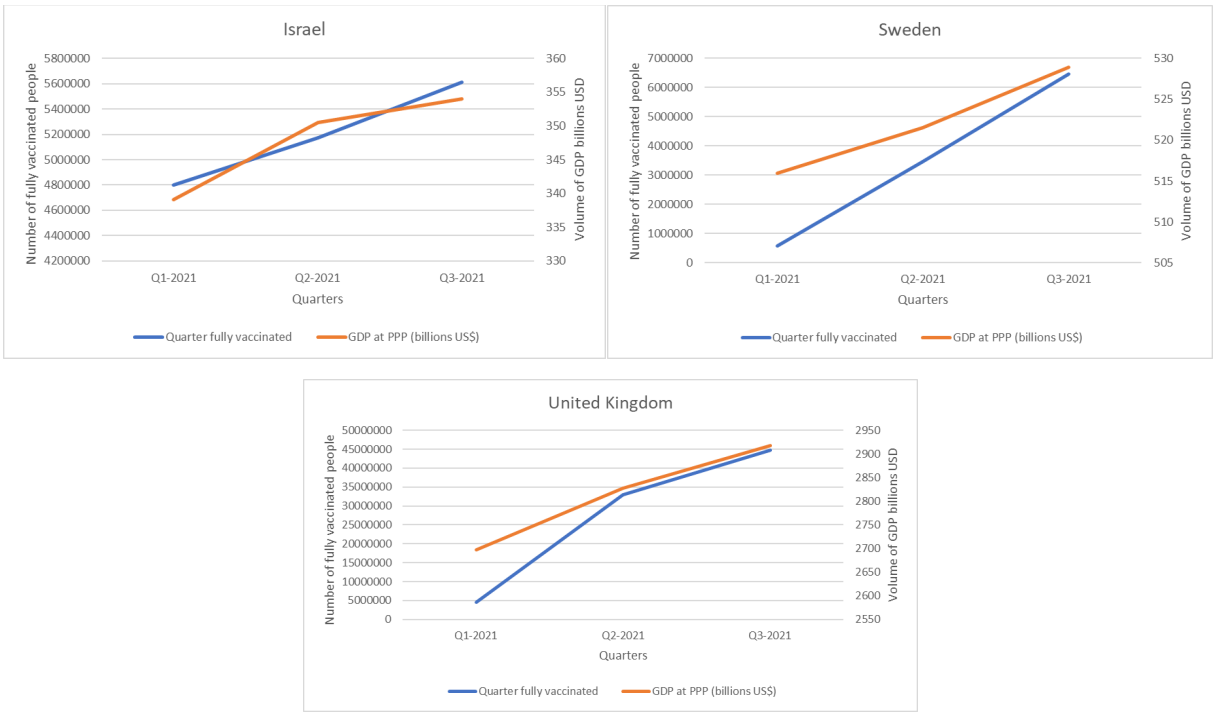
### 4.3.1 Statistical relationship between vaccination measure and GDP

All countries report a positive (direct) statistical relationship between vaccination measure and GDP from the first quarter of 2021 to summer 2021, i.e. an increase of fully vaccinated people generates an increase in GDP.

Figure 14 Statistical relationship between vaccination measure and GDP at PPP, 2021Q1 - 2021Q3





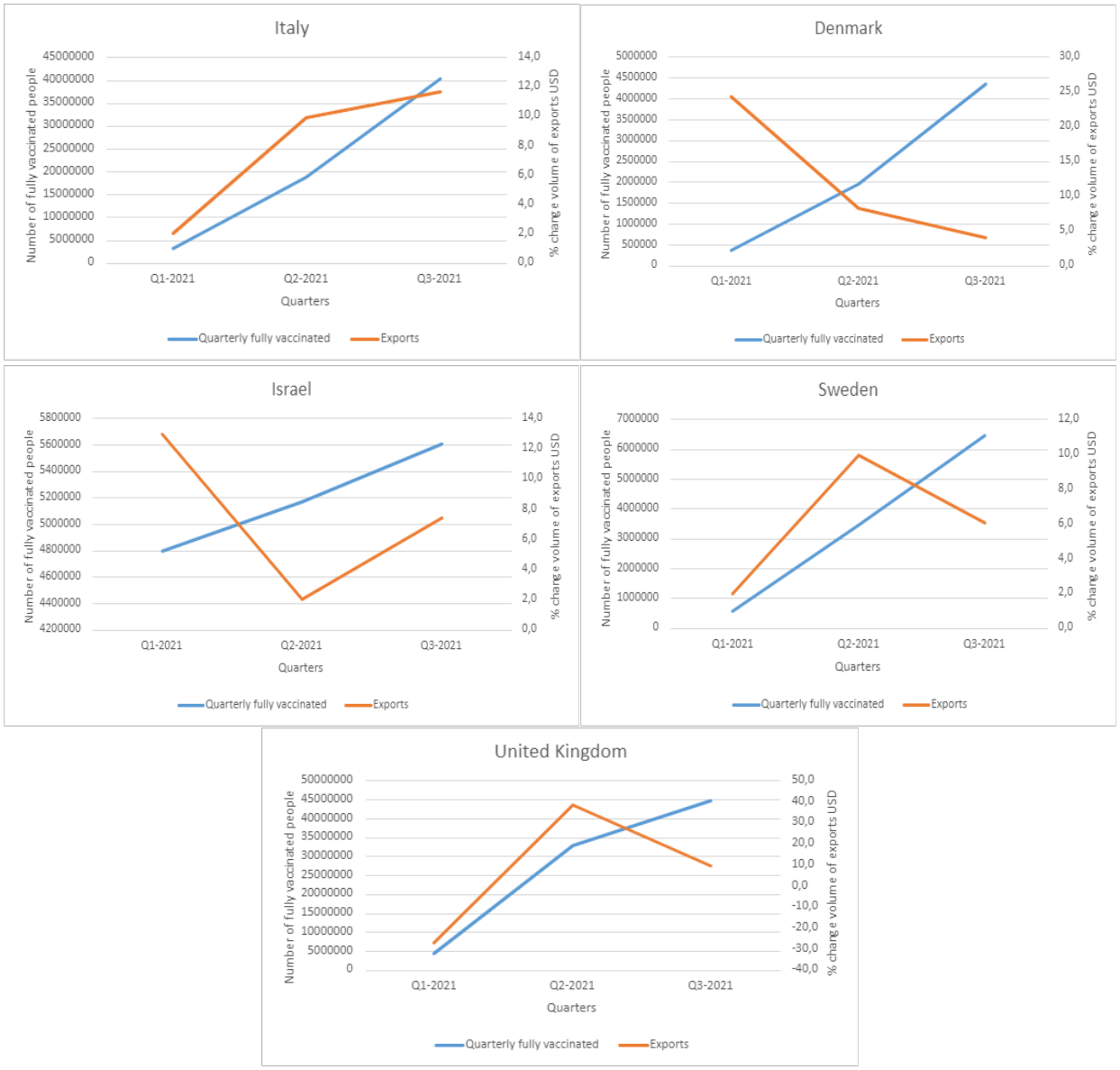

Source: GREEN elaboration based on University Vita-Salute San Raffaele (UNISR) data and OECD Dataset.

Figure 14 shows that vaccination campaigns had a positive impact on economic activities in all countries between the first quarter of 2021 and the third quarter of 2021. An increasing trend of fully vaccinated people over time is followed by an increasing trend of GDP. When the number of fully vaccinated increases significantly, there is no need to implement stricter containment policies, which create high social costs and have negative impacts on national economies. Moreover, when GDP increases, countries can invest more in the health sector to control Covid-19 and provide higher healthcare standards (Alimoradi et al., 2021).

### 4.3.2 Statistical relationship between vaccination measure and exports

The majority of countries have a positive (direct) statistical relationship between vaccination measure and exports from the first to the third quarter of 2021, i.e. an increase of fully vaccinated people is followed by an increase of exports. Italy, Sweden and the United Kingdom report positive (direct) statistical relationships. Denmark and Israel show a negative (inverse) statistical relationship between vaccination measure and exports, revealing that an increase of the number of fully vaccinated people translates into a reduction of exports from early 2021 to summer 2021.

Figure 15 Statistical relationship between vaccination measure and exports of goods and services, 2021Q1 - 2021Q3




Source: GREEN elaboration based on Università Vita-Salute San Raffaele (UNISR) data and OECD Dataset.

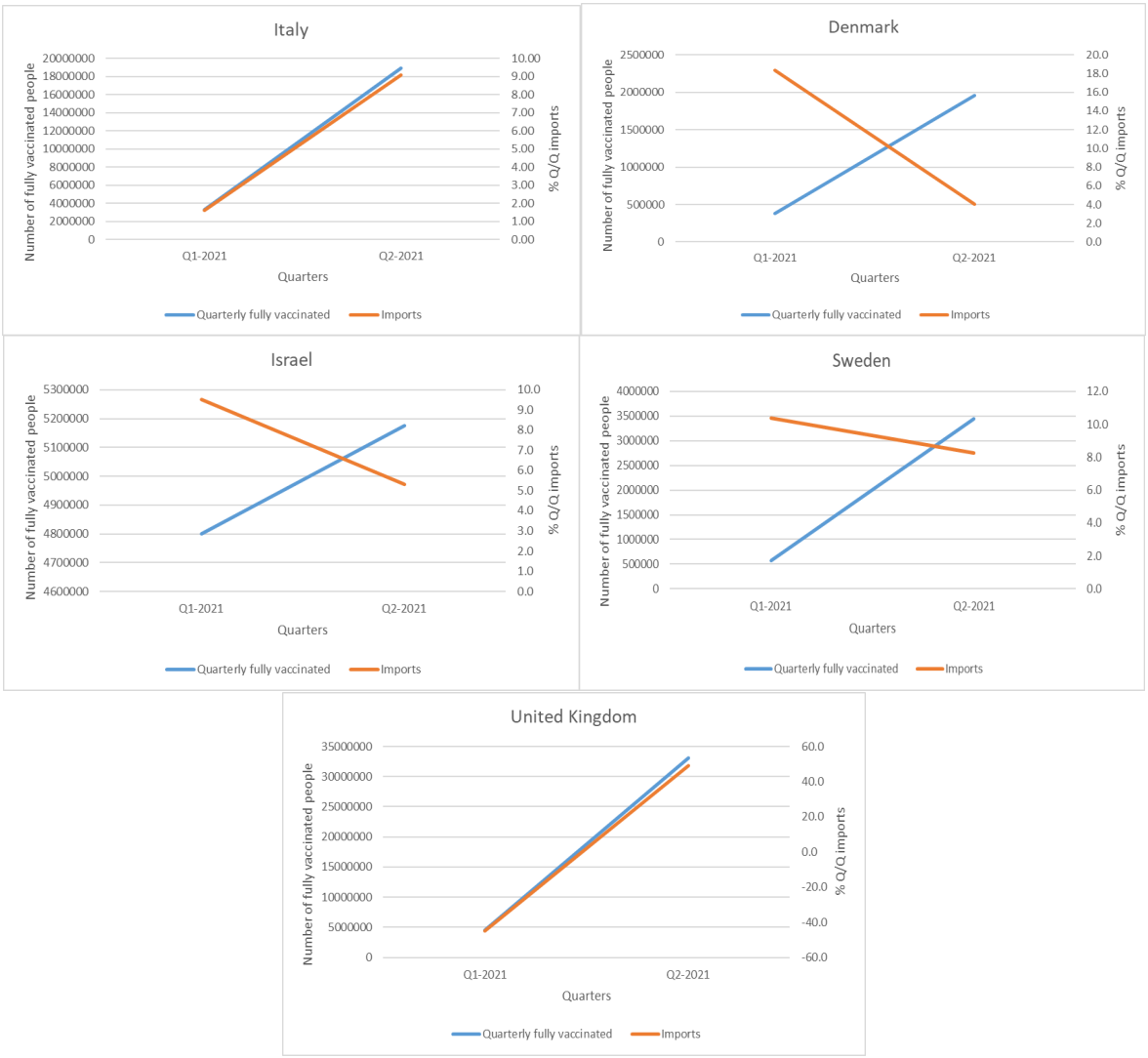
Figure 15 identifies the contribution of vaccination campaigns in generating positive impacts on trade (export) in all countries with the partial exception of Denmark and Israel. Indeed, vaccination campaigns are necessary to keep Covid-19 pandemic under control and, therefore, to limit the adoption of containment policies. Containment policies often have negative impacts on trade (export) activities. Israel experienced different waves periods and earlier vaccination campaigns compared to other countries. This can justify this different statistical relationship in the second quarter of 2021.

### 4.3.3 Statistical relationship between vaccination measure and imports

Italy and the United Kingdom have a positive (direct) statistical relationship between Covid-19 vaccination measure and imports; i.e., an increase of fully vaccinated people generates an increase in

imports. Conversely, Denmark, Israel and Sweden show an inverse (negative) statistical relationship between vaccination and imports, revealing that an increase of fully vaccinated people is followed by a decrease of imports.

Figure 16 Statistical relationship between vaccination measure and imports of goods and services, 2021Q1 - 2021Q3




Source: GREEN elaboration based on University Vita-Salute San Raffaele (UNISR) data and OECD Dataset.

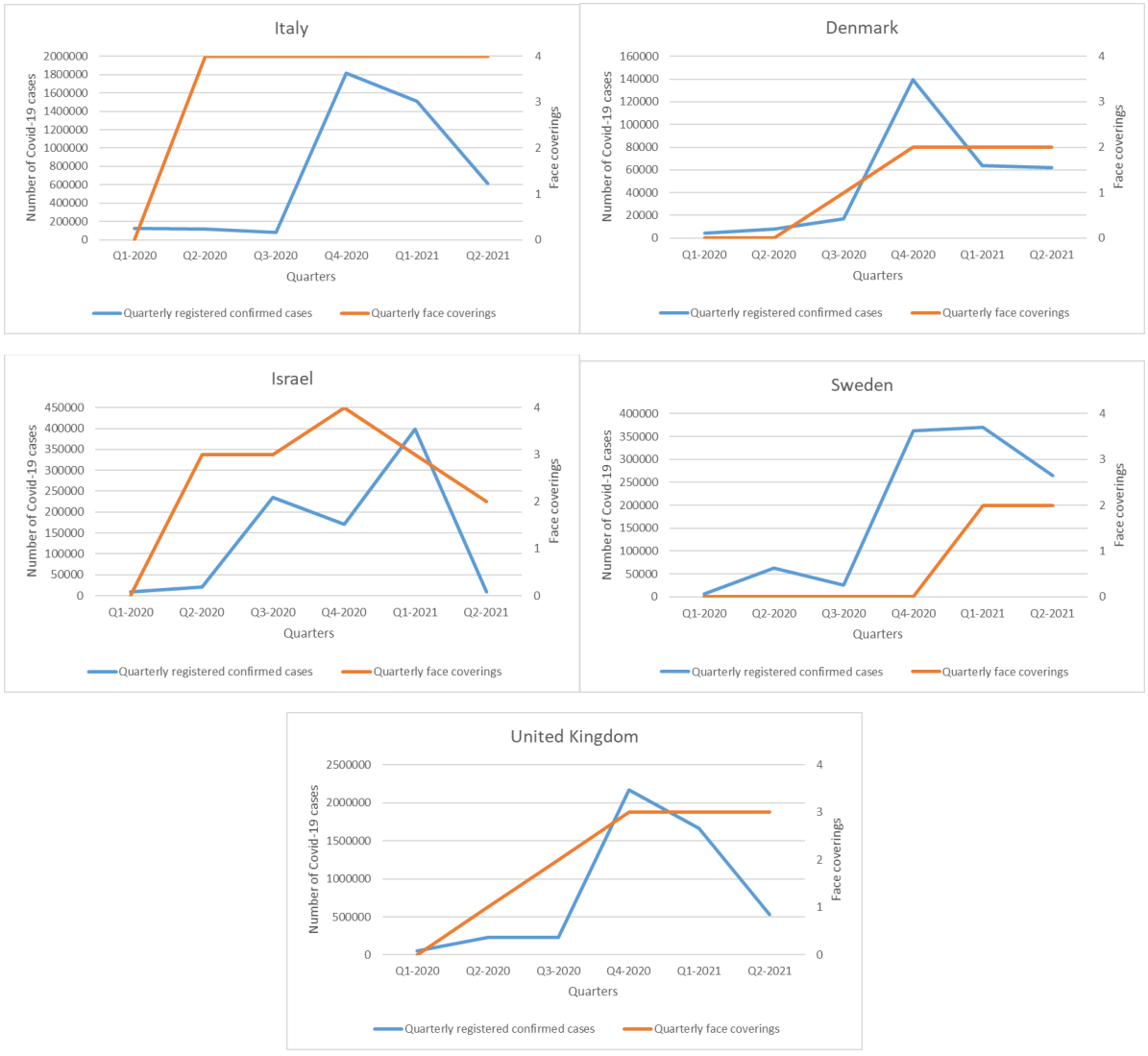
Analysing Figure 16, vaccination campaigns have positive impacts on improving trade activities in Italy and the United Kingdom. The other countries' results may regard country-specific conditions that play an important role in determining the economic impact of Covid-19 vaccines (Deb et al., 2022).

### 4.3.4 Statistical relationships between face covering and Covid-19 cases

All countries – with the exception of Israel – report positive (direct) statistical relationships or no statistical relationships between face covering and Covid-19 cases. Positive (direct) statistical relationships take place when face covering measures do not generate Covid-19 cases decrease. Italy

and Denmark do not show any statistical relationship between face covering and Covid-19 cases from spring 2020 to spring 2021. Israel reports a negative (inverse) statistical relationship, i.e., when the face covering measure becomes stricter the number of Covid-19 cases decrease. Sweden and the United Kingdom have a positive (direct) statistical relationship between face covering and number of Covid-19 cases from spring 2020 to spring 2021. Sweden implemented strict face-covering measures only during short periods, and the UK only during the high peaks of infections. Sporadic and emergency health measures are not able to generate quick effects, especially during the peak of infections.

Figure 17 Statistical relationship between face coverings and number of Covid-19 cases, 2020Q1 - 2021Q2



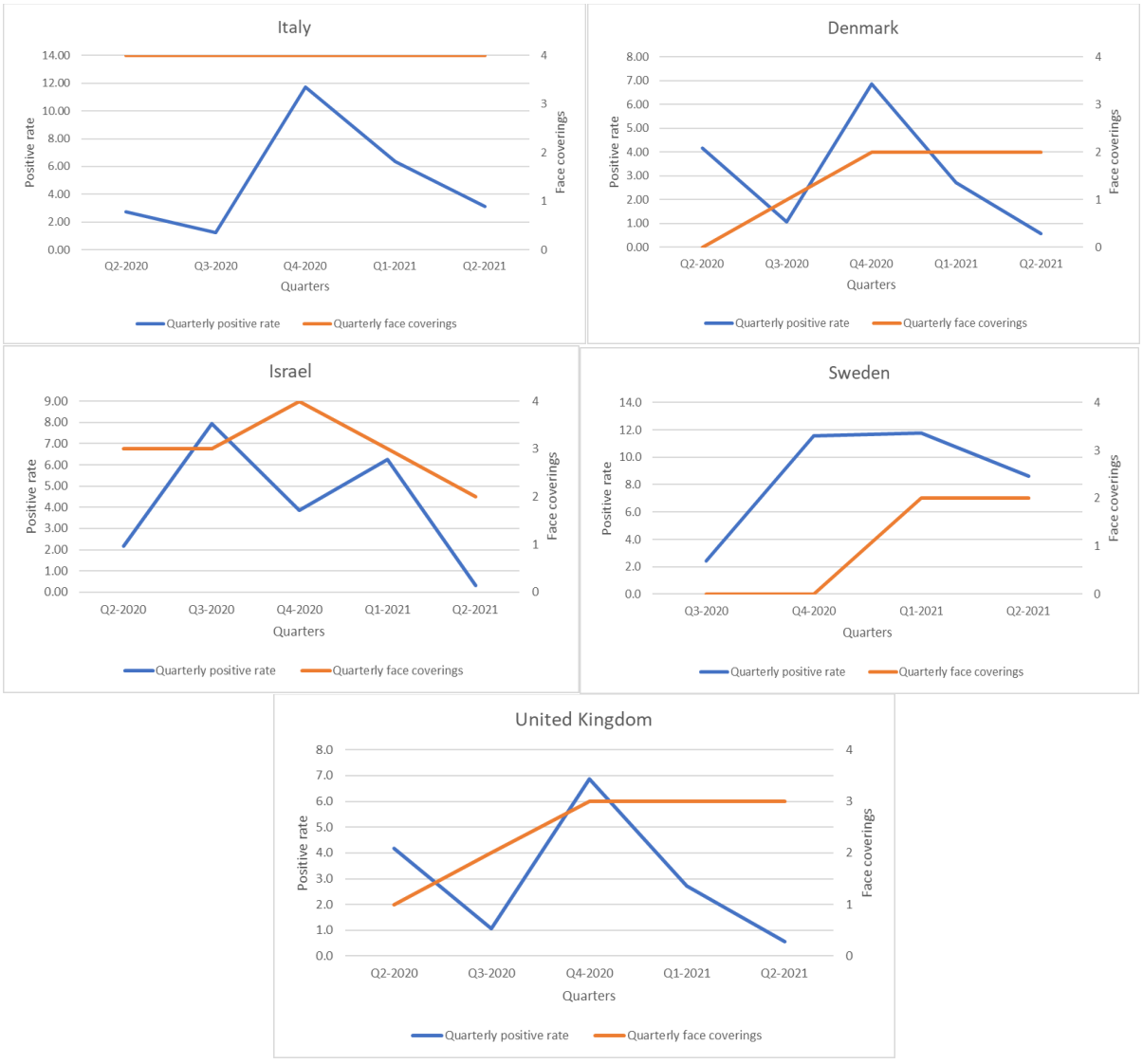

Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and World Health Organization Dataset.

Figure 17 shows direct statistical relationship only in the case of Israel. The face covering measures cannot be implemented alone, but they should be adopted in combination with other health policies (e.g. testing, contact tracing and vaccination campaign) in order to be effective in containing Covid-19 number of infections (Shitrit et al., 2021).

### 4.3.5 Statistical relationships between face covering and positive rate

The five country cases show heterogeneous results from statistical relationships between face covering and positive rate. Italy does not show any statistical relationship, despite the Italian government adopted the maximum level of stringency[29] during the whole period under study. Denmark and Sweden report a positive (direct) statistical relationship, revealing that when measures on face coverings become stricter the positive rate rises. In those cases, the lag effect is evident. Strict face-covering measures are implemented only when Covid-19 infections are extremely high, producing effects only after a long period. Israel and the United Kingdom report an inverse (negative) statistical relationship between measures on face covering and positive rate from spring 2020 to spring 2021, i.e. when measures on face covering become stricter positive rate decreases.

Figure 18 Statistical relationship between face coverings and positive rate, 2020Q2 - 2021Q2




[29] Face masks were compulsory in all indoor and outdoor places outside the home.

Note: Countries adopting health policies on face coverings are grouped into five categories. 0: no policy. 1: recommended. 2: required in some specified shared/public spaces outside the home with other people present, or some situation when social distancing not possible. 3: required in all shared/public spaces outside the home with other people present or all situations when social distancing not possible. 4: required outside the home at all times regardless of location or presence of other people.

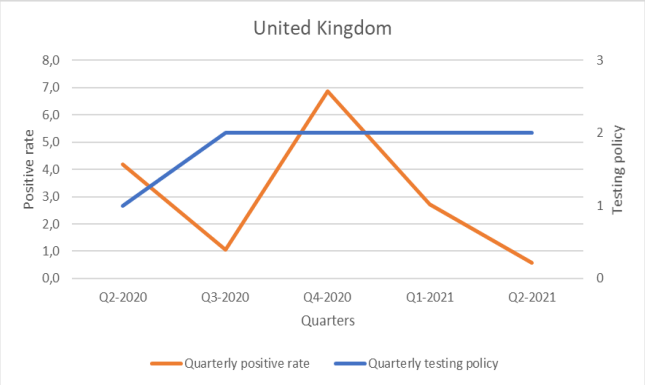
Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and World Health Organization Dataset.

Analysing Figure 18, we find direct statistical relationship between face covering and positive rate in Israel and the United Kingdom. When policies on face coverings become stricter, positive rate decreases in these two countries. However, the reduction of positive rate from early 2021 onwards is mainly related to the vaccination campaigns. Additionally, when face masks are compulsory in all indoor places, they are also effective in reducing the spread of other diseases different from Covid-19, such as influenza (Martin et al., 2020).

### 4.3.6 Statistical relationships between testing measure and positive rate

All countries report a negative (inverse) statistical relationship between testing measure and positive rate from spring 2020 to spring 2021, with a more stringent testing measure (testing asymptomatic and symptomatic people) the positive rate decrease.

Figure 19 Statistical relationship between testing measure and positive rate, 2020Q2 - 2021Q2




Note: The variable on testing measure may assume the following values. 0: no testing measure. 1: Testing only for those who both have symptoms and meet specific criteria (e.g. key workers, admitted to hospital, came into contact with a known case, returned from overseas). 2: testing of anyone showing Covid-19 symptoms. 3: open public testing (e.g. drive through testing available to asymptomatic people).

Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and World Health Organization Dataset.

Figure 19 shows direct statistical relationship between quarterly variations of testing measure and positive rate in all countries during the period under study. Significant statistical relationships are identified when measure on testing reaches the maximum level of intensity, i.e. when also asymptomatic people are tested. In fact, maximizing the number of people that can be tested in a given time is essential to identify and control clusters of infection[30], deploy medical countermeasures in a targeted way and assessing the effectiveness of any public health measures and adapt them accordingly (De Wolff et al., 2020). This is why a well-organized measure on testing can have a positive impact on positive rate reduction, especially if accompanied by successful contact tracing.

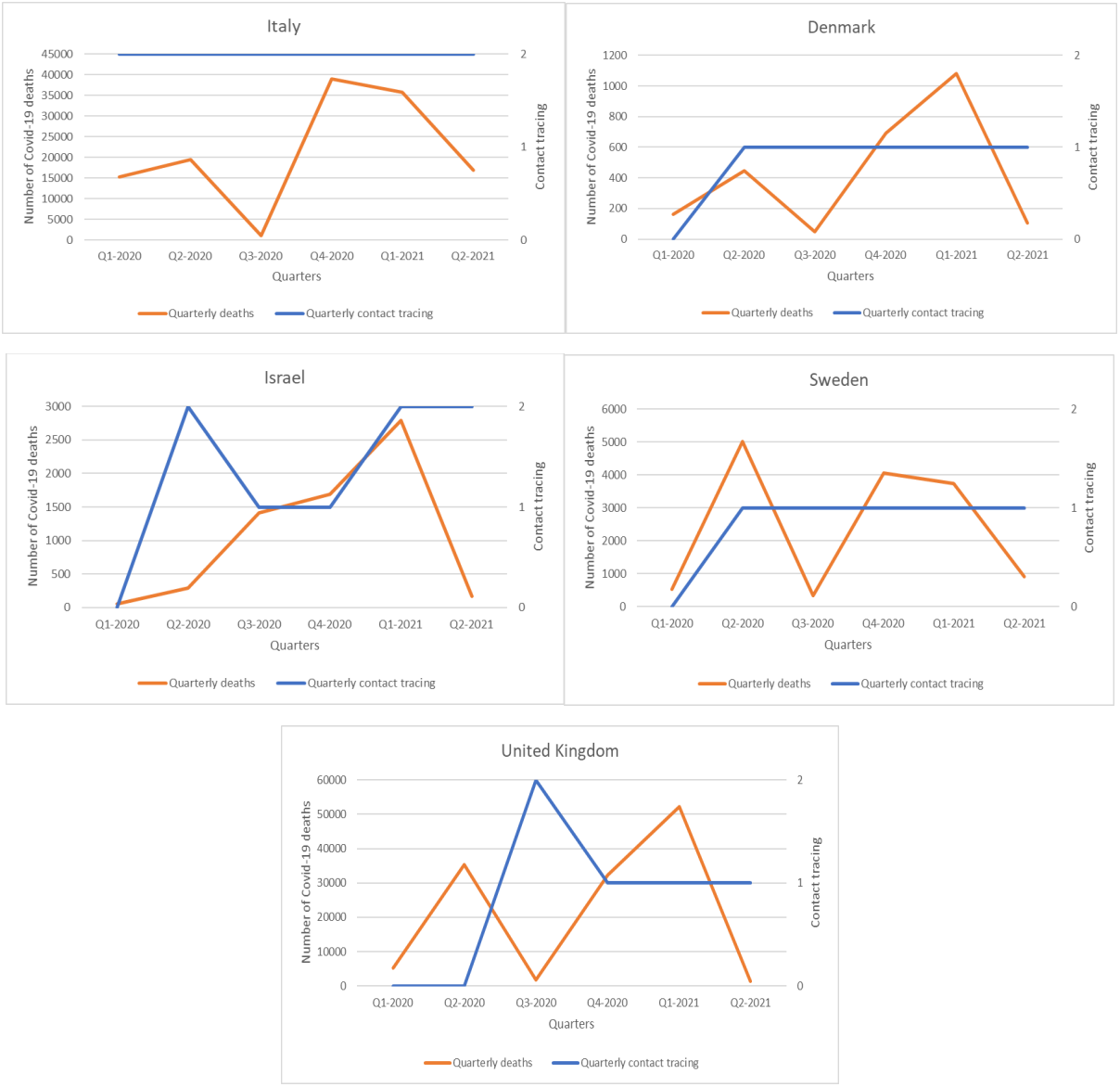
### 4.3.7 Statistical relationships between contact tracing and number of Covid-19 deaths

The majority of countries do not report direct and significant statistical relationship between contact tracing and Covid-19 deaths. Italy, Denmark and Sweden do not report any statistical relationship[31] between contact tracing measure and Covid-19 deaths from the first quarter of 2020 to spring 2021.

Israel and the United Kingdom report an inverse (negative) statistical relationship between contact tracing and number of Covid-19 deaths, because when contact tracing becomes less strict the number of Covid-19 deaths increases.

[30] This helps containing the spread of Covid-19 infections on a larger scale.
[31] Neither positive nor negative.

Figure 20 Statistical relationship between contact tracing and number of Covid-19 deaths, 2020Q1 - 2021Q2




Note: Contact tracing policy may assume the following values. 0: no contact tracing. 1: limited contact tracing – not done for all Covid-19 cases. 2: comprehensive contact tracing – done for all Covid-19 cases.

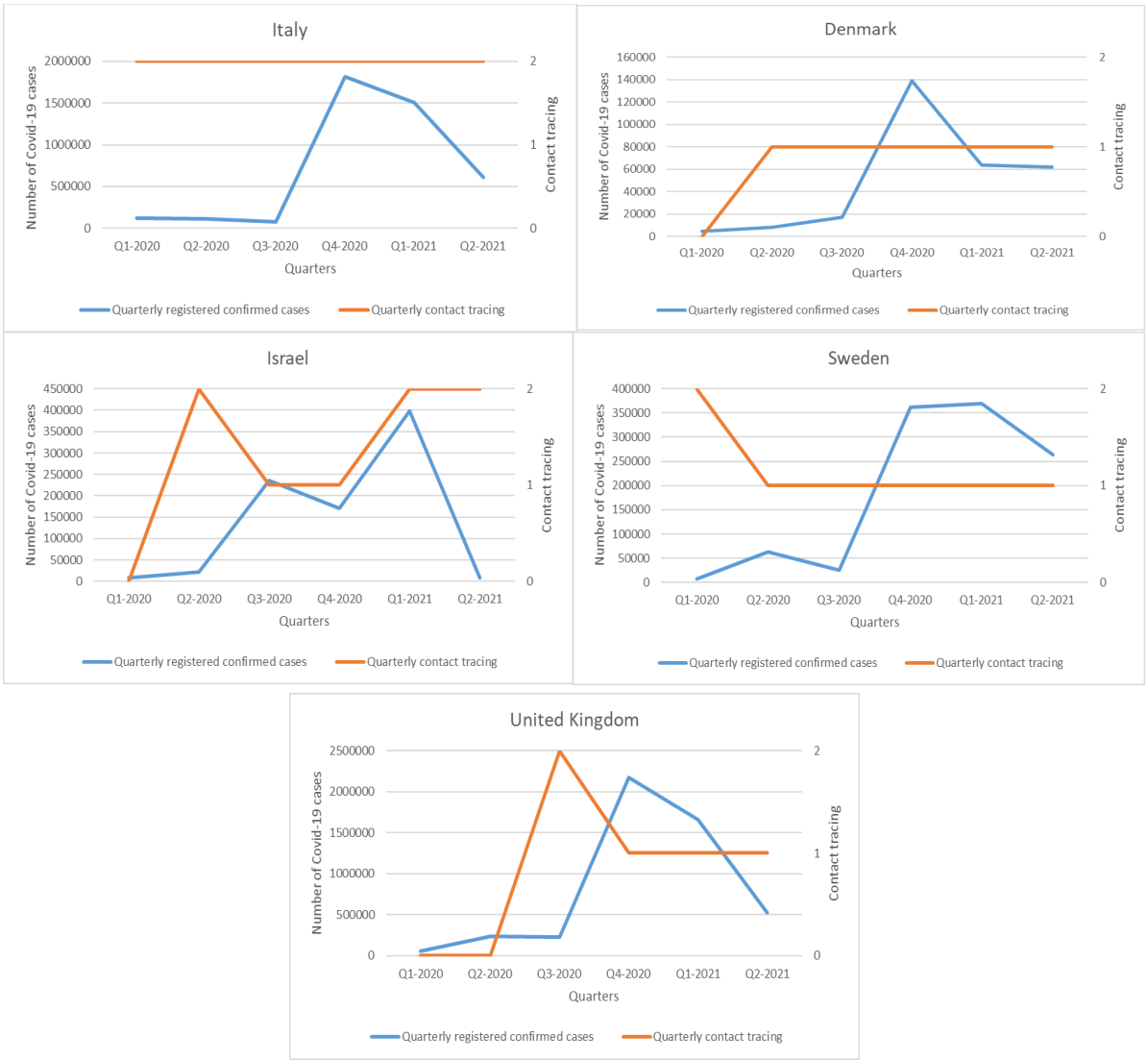
Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and World Health Organization Dataset.

Figure 20 reports that a more comprehensive contact tracing is accompanied by decreasing numbers of Covid-19 deaths in Israel and the United Kingdom. This probably highlights the effectiveness of the health measure on contact tracing in limiting infections and related Covid-19 deaths. Indeed, public health experts consider contact tracing as an indispensable non-pharmaceutical intervention, even as vaccines against Covid-19 have become available (Fetzer and Graeber, 2021).

### 4.3.8 Statistical relationships between contact tracing and number of Covid-19 cases

All countries do not report any direct statistical relationship between contact tracing and Covid-19 cases. Italy, Denmark, Sweden and the United Kingdom do not show any direct statistical relationship between contact tracing and Covid-19 cases. Israel shows an inverse (negative) statistical relationship between contact tracing and Covid-19 cases between early 2020 and the second quarter of 2021, i.e. when measure on contact tracing becomes stricter number of Covid-19 cases reduces.

Figure 21 Statistical relationship between contact tracing and number of Covid-19 cases, 2020Q1 - 2021Q2




Note: Contact tracing measure may assume the following values. 0: no contact tracing. 1: limited contact tracing – not done for all cases. 2: comprehensive contact tracing – done for all Covid-19 cases.

Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and World Health Organization Dataset.

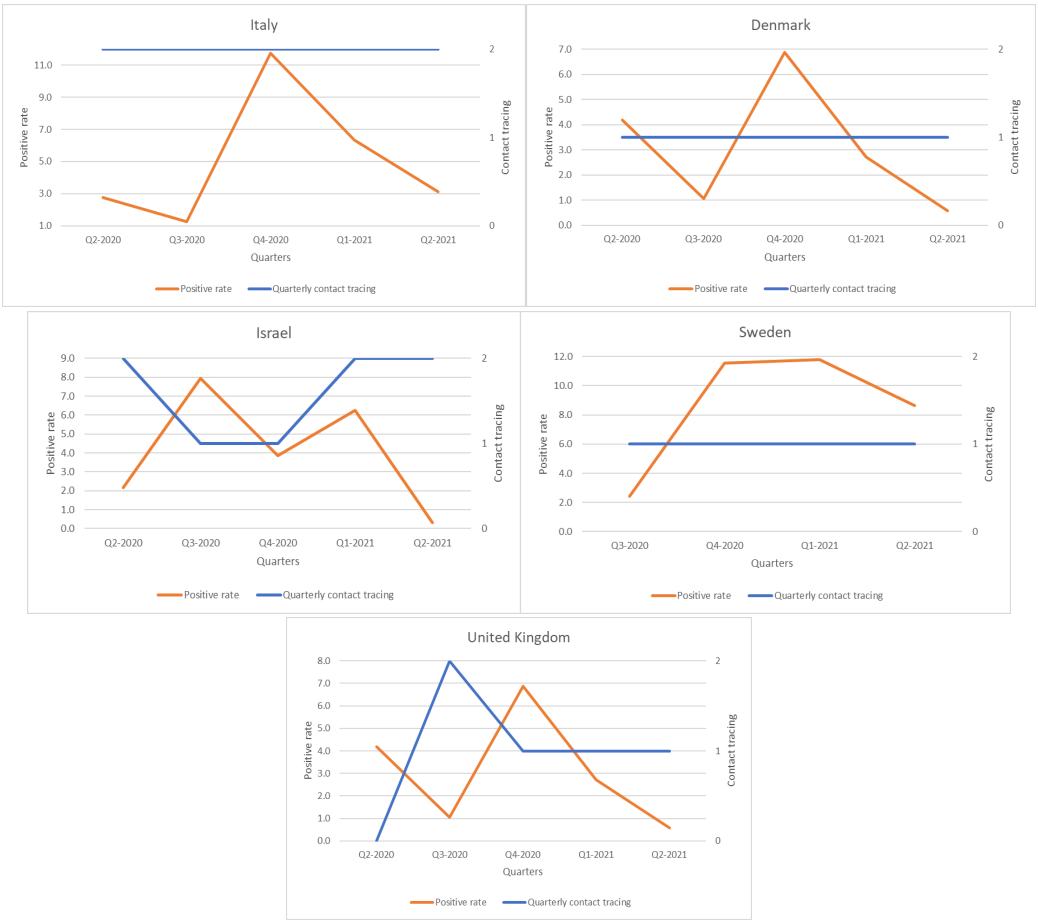
Analysing Figure 21, quarterly variations of contact tracing measure and Covid-19 cases do not show direct relationship in Denmark, Italy, Sweden and the United Kingdom. Nevertheless, we assess direct effects in Israel. Indeed, a weaker contact tracing measure - shifting from comprehensive to limited

contact tracing – generated an increase of Covid-19 cases. This reveals that contact tracing measure adopted by Israel might have been effective in curbing the number of Covid-19 cases when implemented for all Covid-19 cases in a comprehensive way (Altshuler and Hershkovitz, 2020).

### 4.3.9 Statistical relationships between contact tracing and positive rate

The majority of countries do not show direct statistical relationship between contact tracing and positive rate. Italy, Denmark and Sweden do not report any direct statistical relationship between contact tracing and positive rate between spring 2020 and spring 2021. Israel and the United Kingdom show an inverse (negative) statistical relationship between contact tracing and positive rate from the second quarter of 2020 to spring 2021, i.e. when contact tracing measure becomes stricter positive rate decreases.

Figure 22 Statistical relationship between contact tracing and positive rate, 2020Q2 - 2021Q2




Note: Contact tracing measure may assume the following values. 0: no contact tracing. 1: limited contact tracing – not done for all cases. 2: comprehensive contact tracing – done for all cases.

Source: GREEN elaboration based on Oxford Covid-19 Government Response Tracker Database and World Health Organization Dataset.

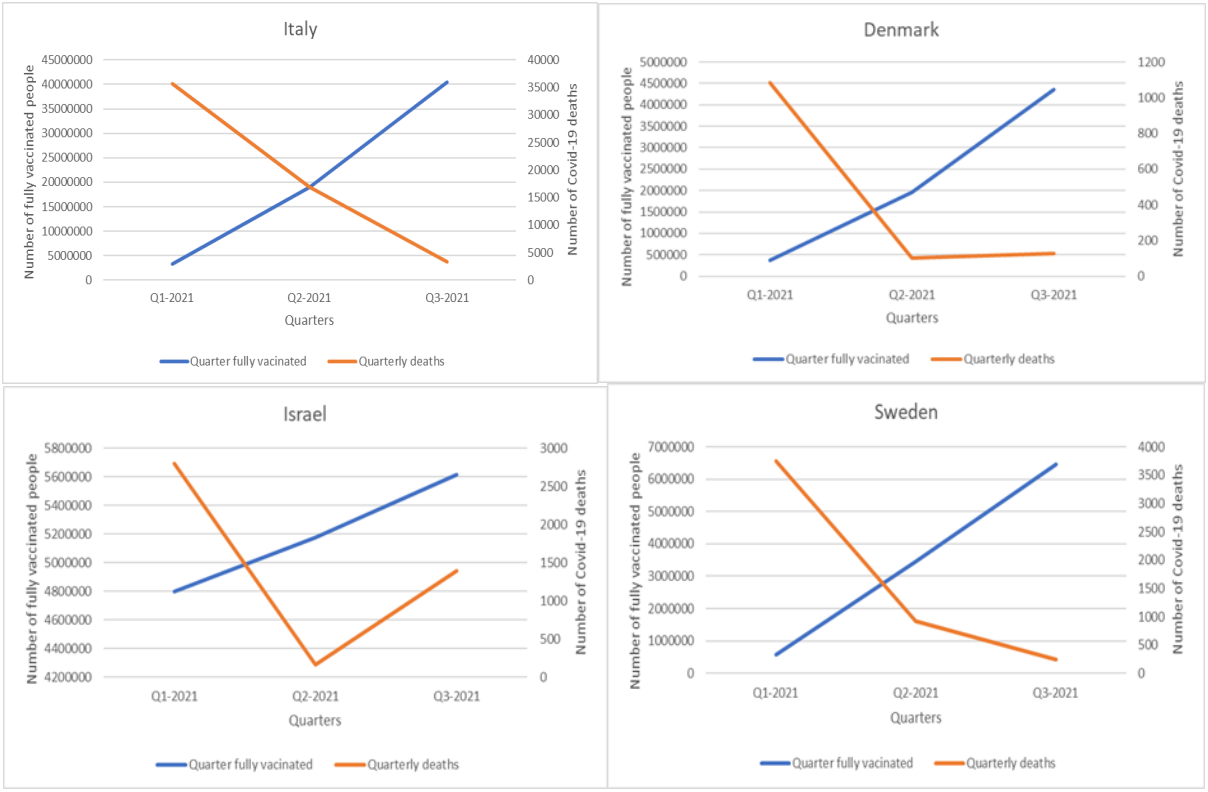
Israel and the United Kingdom show high significance concerning statistical relationship between contact tracing and positive rate, because stricter measures of contact tracing are accompanied by a reduction of positive rate (i.e. Covid-19 spread among the population). We also consider a lag effect in our analysis. A reduction of positive rate may occur after the adoption of stricter contact tracing.

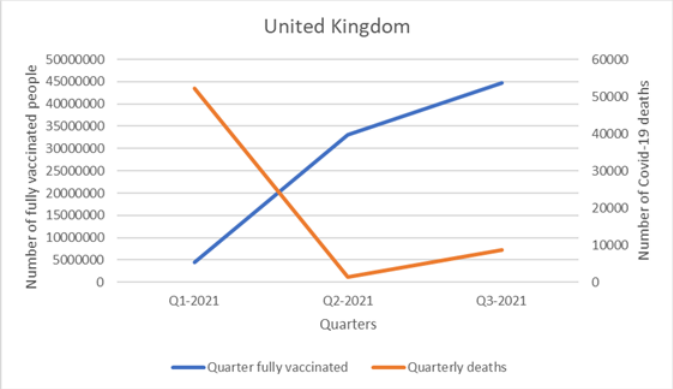
Conversely, a less strict measure on contact tracing (i.e. limited contact) may not be effective in containing the increase in positive rate when cases raise quickly.

### 4.3.10 Statistical relationships between vaccination measure and number of Covid-19 deaths

The majority of countries shows an inverse (i.e. negative) statistical relationship between vaccination measure and Covid-19 deaths, i.e. an increase of fully vaccinated people generates a decrease of Covid-19 deaths. Italy, Denmark and Sweden report an inverse (i.e. negative) statistical relationship between vaccination measure and Covid-19 deaths between the first and third quarter of 2021. Israel and the United Kingdom have a negative (inverse) statistical relationship from the first to the second quarter of 2021. A positive statistical relationship is identified in summer 2021, considering that those two countries show an increase of Covid-19 deaths despite the increase of the number of fully vaccinated people. However, the increase of the number of fully vaccinated people had a slowdown in summer 2021 with respect to spring 2021, especially in the United Kingdom. These variations are connected to the Delta variant spread in the UK, and a different wave time in Israel which had approved the booster shot earlier than in other countries.

Figure 23 Statistical relationship between vaccination measure and number of Covid-19 deaths, 2021Q1 - 2021Q3






Source: GREEN elaboration based on University Vita-Salute San Raffaele data and World Health Organization Dataset.

Analysing Figure 23, we identify direct statistical relationship between vaccination measure and Covid-19 deaths. Vaccinations allowed to keep the pandemic under control and to lift containment policies, with a reopening of commercial activities. In the United Kingdom[32], Covid-19 cases restarted to rise in summer 2021 because of a slowdown of the vaccination campaign that was not sufficiently effective in coping with the spread of the Delta variant of SARS-CoV-2 virus (Pouwels et al. 2021).

### 4.3.11 Synthesis of statistical relationships between health policies and socio-economic, health data

The statistical relationships between health policies and socio-economic data show direct relationships in all countries only when vaccination campaign is considered. Vaccination campaign – measured in terms of number of fully vaccinated people[33] - shows direct economic effects. The progressive increase of fully vaccinated reduces the need for strict containment policies, with lower social costs and less negative impacts on national economic performance. Statistical relationships between health policies and health variables show heterogeneous results among the five country cases. Measure on face covering does not show direct statistical relationship with Covid-19 cases variations across quarters, with the partial exception of Israel. A higher strictness of face coverings measure is accompanied by a reduction of Covid-19 cases in Israel. However, it is difficult to identify the direct impact of this measure on Covid-19 spread. Moreover, the measure on face coverings was not implemented alone but in combination with other health policies (e.g. testing, contact tracing and vaccination campaigns, Shitrit et al., 2021). Statistical relationships between contact tracing and health variables do not show direct effects, with the exception of Israel and the United Kingdom. A stricter contact tracing measure (done for all Covid-19 cases) generated a decrease of Covid-19 deaths and Covid-19 cases in Israel and the United Kingdom. The vaccination campaign is the health measure that shows stronger and direct statistical relationship with health variables. When the number of fully vaccinated people increases, Covid-19 deaths, Covid-19 cases and positive rate reduce in all countries.

# 5 Relevance assessment of statistical relationships between policy responses and socio-economic, health data and environmental data

This section assesses the relevance of statistical relationships between policy responses and socio-economic, health and environmental variables in the five study cases. This analysis aims to evaluate

[32] This also happened in Denmark and Israel.
[33] People who received two doses of Covid-19 vaccine.

which policy response generates direct effects on human health and socio-economic variables and identify differences among countries in terms of policy efficacy.

To evaluate the relevance of Covid-19 policy responses, we designed a matrix of relevance (Table 3) considering the three groups of policy responses: containment policies, economic support policies and health policies. Containment policies aim at minimizing the risk of virus transmission from infected to non-infected individuals. Economic support policies aim at supporting national economies, by mitigating the negative effects of containment policies. Health policies aim to reduce Covid-19 infections and deaths. Per each category of policies, we assessed Covid-19 measure responses by looking at their capacity to reduce impacts on health, socioeconomic and environmental variables for each country. Statistical relationships are relevant when direct relationships between response measures, and socio-economic and health variables are observed (e.g., when policy response has been effective in mitigating socio-economic and health impacts of Covid-19 outbreak); otherwise, they are considered not relevant. This allows identifying which policies and measures have been more effective in reducing pandemic effects in each country and understanding differences in terms of country approach.

Table 3 Matrix of relevance (statistical relationships between policy responses and socio-economic, health and environmental data), 2020Q1 - 2021Q2

| | **Country data** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Government response policies to the pandemic** | **Health data** | | | **Socioeconomic data** | | | | | **Environmental data** |
| **Health policies** | Deaths | Covid-19 registered confirmed cases | Positive rate | GDP | Import | Export | Unemployment rate | Youth unemployment rate | CO2 emissions |
| Face coverings *(influenced by containment policies) | NR<br>EV | R= IS<br>EV | R= IS+UK<br>EV<br>reduction other diseases | NR | NR | NR | NR | NR | NR |
| Testing policy | NR | NR | R | NR | NR | NR | NR | NR | NR |
| Contact tracing | R=IS+UK<br>EV | R= IS | R= IS+UK<br>EV | NR | NR | NR | NR | NR | NR |
| Vaccination campaign | R | R | R | R | R= IT+UK | R=<br>IT+SW+UK | NR | NR | NR |
| | | | | | | | | | |
| **Economic policy responses** | | | | | | | | | |
| Debt relief | NR | NR | NR | R= DK +<br>UK<br>EV | NR | R= IS | NR | NR | NR |
| Income support | NR | NR | NR | R= SW +<br>IS + UK | NR | NR | R=UK + DK | R=UK | NR |
| | | | | | | | | | |
| **Containment policies** | | | | | | | | | |
| Stringency index | R(lag effect) | R=DK + SW<br>EV | R= DK | R | R | R | R= SW | R=DK | R (lag effect) |

Note (a): Legend statistical relationships:

| | |
|---|---|
| R | Relevant (country acronym shows a high relevance for that country) |
| NR | Not relevant |
| EV | Policy evolution |
| * | Data bias existing |

Source: GREEN elaboration.

Two main results emerge from the analysis: 1. not all policies and measures implemented were able to generate direct effects on socio-economic and health variables, showing low relevance grades; 2. policies and measures' relevance differs among countries analysed. In detail, containment policies

generated impacts in all countries, especially on economic variables (i.e. GDP fall and reduction of trade activities) and environmental variables (CO2 reduction). This is particularly clear during the first (2020Q1 – 2020Q2) and second (2020Q4 - 2021Q1) waves of Covid-19 pandemic, when lockdowns were more generalized and stricter. These results are in line with many studies which find that stricter lockdowns are associated with more important falls in economic and trade activities (Egert et al., 2020; Hayakawa and Mukunoki, 2021; IMF, 2020). Containment policies are effective also in reducing Covid-19 deaths in all countries. Stricter containment policies are followed by decreasing Covid-19 deaths, by considering a temporal lag. Statistical relationships between containment policies and other health dimensions are relevant only in the case of Denmark (Covid-19 cases and positive rate) and Sweden (Covid-19 cases). The efficacy of (soft) but successful lockdown measures in those two countries in reducing Covid-19 spread is in line with the findings of Andersen et al. (2020) and Torry (2021). Reduction of Covid-19 cases in those two countries could be related to a low population density, which reduces the risk of infection spread. Indeed, 90% of reported Covid-19 cases are concentrated in urban areas, where the high density provides an ideal environment for infections to erupt, and fast. Finally, containment policies show high relevance in generating co-benefits, such as CO2 emissions reduction, by considering a temporal lag effect (Menut et al., 2020). This is particularly clear during the first wave of Covid-19 pandemic, when lockdown measures were harsher and spread worldwide (Aruga et al., 2021). Conversely, the reduction of containment policies provoked a quick rise of CO2 emissions especially in cities, due to an increase of private cars to avoid crowded public transport.

Economic measures show a limited relevance in minimizing the negative impacts of containment policies. Direct effects emerge only when economic support policies are adopted with the maximum level of public spending. Precisely, when both debt relief measures and economic support to households are strongly implemented by a country. For instance, debt relief measures – aimed at reliving companies' debts - have been effective in containing GDP losses in Denmark and the United Kingdom (Andersen,2021; Witteveen, 2020), where economic support for businesses has been more consistent. Likewise, families' income support measures have been effective in contrasting GDP and job loss in countries with high investments in terms of economic support (e.g. the United Kingdom).

Health policies show high relevance in reducing the impact on human health. The most relevant health measure is the vaccination campaign. Indeed, the vaccination measure has been effective in reducing Covid-19 deaths, Covid-19 cases and the positive rate in all countries. Health measures on contact tracing show relevance in containing Covid-19 deaths and the positive rate in the United Kingdom and Israel. This relates to high investments made by these two countries to set up a local infrastructure aimed at successfully identifying clusters of Covid-19 infections (see for instance Fetzer and Graeber, 2021). Overall, health measures on face-covering do not show high relevance – with the partial exception of Israel. Studies on the effectiveness of face masks (Clapp et al., 2020) report moderate protective effects of face masks against Covid-19, both in terms of personal protection as well as source control (protection of others). Among different types of face masks, FFP2 face masks are the most effective by reducing more than 95% of droplets[34]. However, the effective impact of this measure is hard to define, due to a stricter introduction during lockdown periods. The accomplishment of face-covering measures is also difficult to control by public authorities and strongly depends on psychological factors such as risk compensation behaviour, stigma, and symbolism around wearing a mask. Health policies show low relevance in generating economic and environmental impacts. The

[34] However, Clapp et al. (2020) state that the exact percentage of filtration efficiency required to prevent respiratory virus transmission is not precisely known.

only health measure which shows effectiveness in mitigating economic impacts – especially in terms of GDP loss – is the vaccination campaign by reducing the need for stricter containment policy with high socioeconomic impacts.

Finally, it is important to consider that policy categories and related measures are never implemented alone. Rebound effects might alter the identification of direct impacts. Indeed, policies and measures have been implemented within a mixed and complex policy package. This makes it difficult to evaluate the impact or effectiveness of a single policy and measure, suggesting the need to look at the national approach or model set up to cope with Covid-19 pandemic.

## 6. National policy response models

The matrix of relevance shows how Covid-19 policy responses generate different effects in the five case studies. This mostly depends on the policy approach selected by countries, which differ according to three factors: 1. strictness of policy/measure, 2. duration, and 3. public spending. Identifying the different national policy approaches is necessary to evaluate the effectiveness in reducing the pandemic impacts on human health, economy and environment. In order to identify and categorize countries' approaches, we set up a stringency assessment matrix. Per each policy category, we considered only measures implemented by all case studies within two years of the pandemic to assure comparability. Each measure has been classified according to its severity and intensity from high to low. Table 4 describes the criteria used for assessing the stringency level of Covid-19 measures.
Stringency assessment criteria have been defined considering Oxford Tracker criteria and our analyses on national Covid-19 policy evolution. Data availability has been considered in criteria definition. For instance, the stringency criteria for assessing economic support measures to households differs from the ones defined for economic support to companies. The first one considers only one support measure, i.e. coverage of lost salary. Stringency assessment criteria for economic support to companies considered three types of support measures: 1. Stopping loan repayments; 2. Preventing services like water from stopping; 3. Banning evictions. For the three measures, the lack of data among countries made it difficult to identify quantitative threshold as we did for the economic support measure targeted at households. For this reason, we decided to attribute a high level of strictness when government provides all types of support measures.

Table 4 Strictness level definition of Covid-19 policy responses, 2020 - 2021

| **Policy responses** | | **Strictness level** | | |
|---|---|---|---|---|
| | | **High** | **Medium** | **Low** |
| **Containment policies** | Lockdown | 1 or more lockdowns of more than 3 months | 1 lockdown of between 1 and 3 months | No lockdown at all or 1 lockdown of less than 1 month |
| | Digital Covid-19 Certificate | Mandatory to access all types of shared/public spaces and to travel | Mandatory to access specific places and to travel abroad | Not adopted or only adopted for travelling abroad |
| **Economic support policies** | Economic support to households | Economic support aimed at covering 50% or more of lost salary | Economic support aimed at covering less than 50% of lost salary | No economic support or very limited economic support |
| | Economic support to companies | Broad debt relief (all types of support measures) | Narrow debt relief (only one support measures) | No economic support or very limited economic support |

| | | | | |
|---|---|---|---|---|
| **Health policies** | Face coverings | Required in all shared/public spaces at any times | Required in some specified shared/public spaces | No policy or simply recommendation |
| | Testing | Open public testing (including asymptomatic people) | Testing of anyone showing Covid-19 symptoms | No policy or testing only for those who both have symptoms and meet specific criteria (e.g. key workers) |
| | Contact tracing | Comprehensive contact tracing (done for all Covid-19 cases) | Limited contact tracing (not done for all Covid-19 cases) | No policy or very limited contact tracing |
| | Vaccination campaign | Share of fully vaccinated population over 80% | Share of fully vaccinated population between 60% and 80% | Share of fully vaccinated population below 60% |
| None | | It means that the policy did not exist that year (e.g., vaccination campaign in 2020) | | |

Source: GREEN elaboration.

After defining the criteria, we assigned the corresponding stringency level to each Covid-19 measure implemented by the five national governments (Table 5). The assessment has been carried out based on data coming from the Oxford Covid-19 Government Response Tracker and our analysis concerning national Covid-19 policy evolution and characteristics. We consider two years of measures' implementation in this assessment: 2020 and 2021.

Table 5 Strictness levels of Covid-19 measure responses adopted by five countries, 2020 – 2021

a) Containment policies

| **Policy responses** | | **Containment policies** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Lockdown** | | | **Digital Covid-19 Certificate** | | |
| Countries | Years | Low | Medium | High | Low | Medium | High |
| Italy | 2020 | | | X | None | | |
| | 2021 | | | X | | | X |
| Denmark | 2020 | | X | | None | | |
| | 2021 | X | | | X | | |
| Israel | 2020 | | X | | None | | |
| | 2021 | X | | | | | X |
| Sweden | 2020 | X | | | None | | |
| | 2021 | X | | | X | | |
| The United Kingdom | 2020 | | | X | None | | |
| | 2021 | | X | | | X | |

b) Economic support policies

| **Policy responses** | | **Economic support policies** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Economic support to households** | | | **Economic support to companies** | | |
| Countries | Years | Low | Medium | High | Low | Medium | High |
| Italy | 2020 | | X | | | X | |
| | 2021 | | X | | | | X |
| Denmark | 2020 | | | X | | | X |
| | 2021 | | | X | X | | |
| Israel | 2020 | | | X | | | X |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2021 | | | X | | X | |
| Sweden | 2020 | | | X | | X | |
| | 2021 | | | X | X | | |
| The United Kingdom | 2020 | | | X | | | X |
| | 2021 | | | X | | | X |

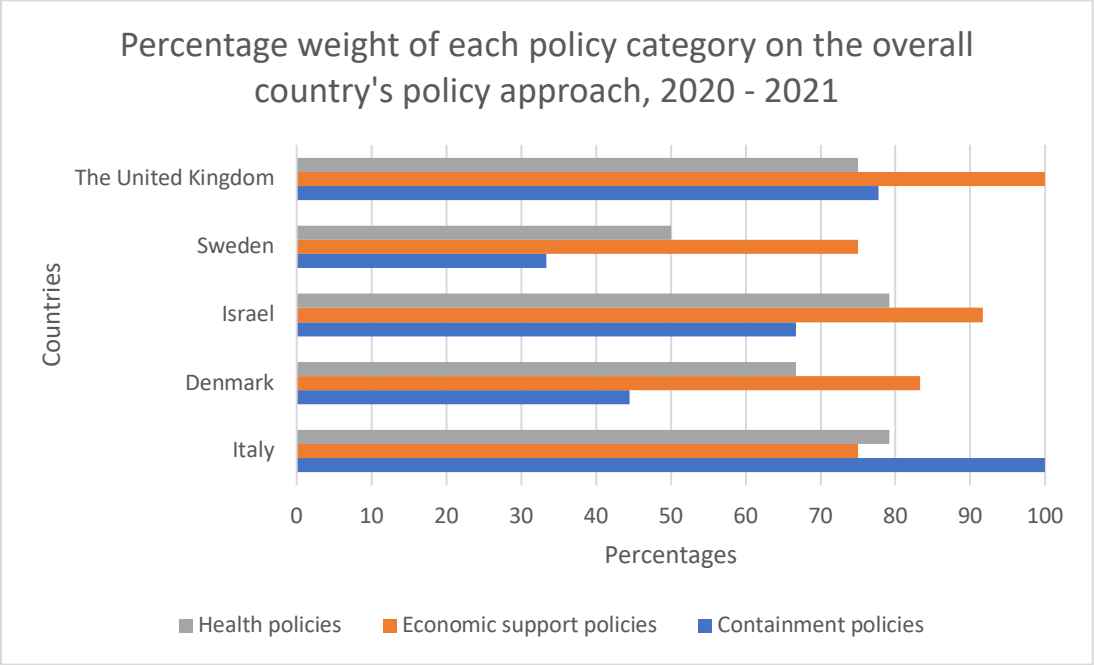
c) Health policies

| **Policy responses** | | **Health policies** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Face coverings** | | | **Testing** | | | **Contact tracing** | | | **Vaccination campaign** | | |
| | | Low | Medium | High | Low | Medium | High | Low | Medium | High | Low | Medium | High |
| Italy | 2020 | | | X | | X | | | | X | None | | |
| | 2021 | | | X | | | X | | X | | | | X |
| Denmark | 2020 | X | | | | | X | | X | | None | | |
| | 2021 | | X | | | | X | | X | | | | X |
| Israel | 2020 | | | X | | X | | | X | | X | | |
| | 2021 | | X | | | | X | | | X | | | X |
| Sweden | 2020 | X | | | | X | | | X | | None | | |
| | 2021 | X | | | | X | | X | | | | | X |
| The United Kingdom | 2020 | | X | | | X | | | | X | X | | |
| | 2021 | | X | | | X | | | | X | | | X |

Source: GREEN elaboration.

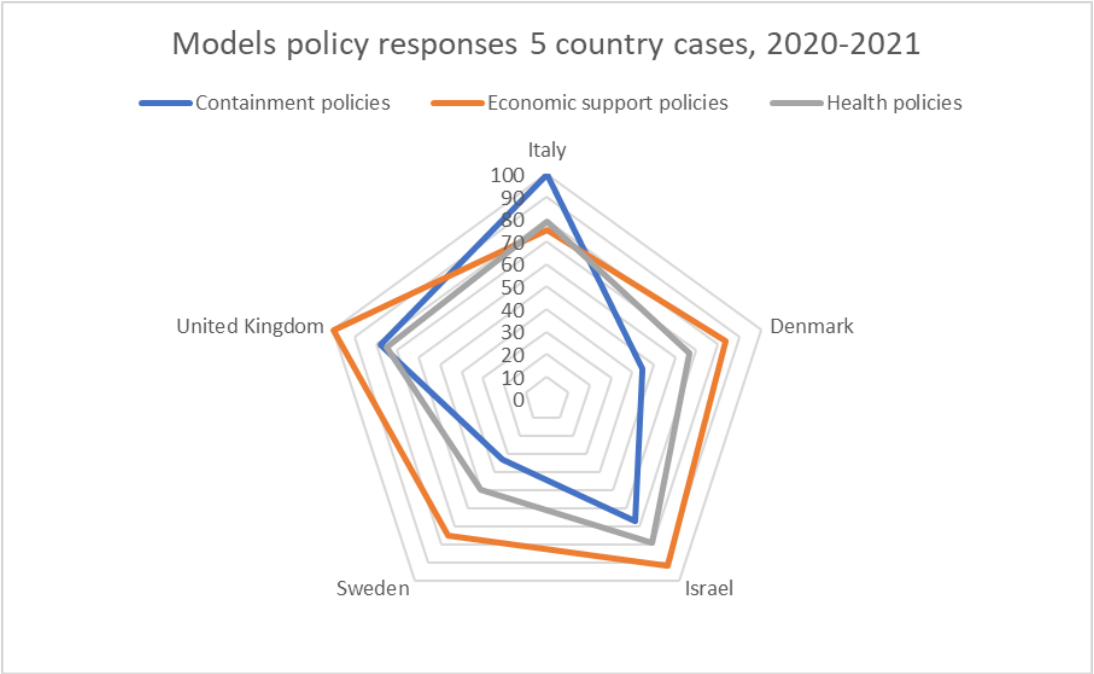
Based on Table 5, we assigned numerical scores to stringency levels. Namely, we attributed a score of 1 if the level of stringency is low; 2 if the level of stringency is medium; 3 if the level of stringency is high. For each policy category, scores have been summed up, considering two years of analysis (2020-2021). Then, the total scores have been translated into percentages in order to understand the weight and significance of each policy category on the overall country's policy approach. Figure 24 shows the weight of each policy category in each country case.

Figure 24 Percentage weight of each policy category on the overall country's policy approach, 2020 - 2021




Note: level of strictness policy responses: 1-40% = low; 41-70% = medium; 71-100% = high.
Source: GREEN elaboration.

Figure 25 Models policy responses of five countries, 2020 - 2021




Note: level of strictness policy responses: 1-40% = low; 41-70% = medium; 71-100% = high.
Source: GREEN elaboration.

This analysis allowed us to identify five national models of policy responses[35]: Italy, Denmark, Israel, Sweden and the United Kingdom.

The Italian model is characterised by strict containment policies, i.e. severe and prolonged lockdowns and wide use of the Digital Covid-19 Certificate, required to access all public spaces. A strong interest is devoted to health policies, especially vaccination campaigns. Conversely, the Italian model pays less attention to economic support policies, providing moderate economic support to households and moderate-high support to companies.

The Danish model is characterised by strong economic support policies - particularly directed to family incomes – and high adoption of health policies (i.e. vaccination campaigns and testing). Conversely, the Danish model is less concentrated on containment policies, with short and less strict lockdowns and low use of the Digital Covid-19 Certificate.

The Israeli model is characterised by strong economic support, especially aimed at families' income; high health policies adoption, with an earlier and well-organised vaccination campaign. The Israeli model is also characterised by moderate adoption of containment policies, i.e. less strict lockdowns but high use of the Digital Covid-19 Certificate.

The Swedish model is similar to the Danish one. The Swedish model is characterised by high economic support policies, with special regard for family incomes; and low intense health policies (e.g. face masks are not mandatory). The Swedish model is also characterised by low containment policies adoption, both lockdowns and the Digital Covid-19 Certificate were less implemented and with lower strictness compared to other models.

The UK model is characterised by high economic support policies (both for companies and households), and strong attention to health policies, i.e. vaccination campaign and contact tracing measures. The UK model is also characterised by high adoption of containment policies, i.e. strict lockdowns but less than in the Italian model. Indeed, lockdowns in the UK were strict but less prolongated than in Italy. Moderate attention is paid to the use of the Digital Covid-19 Certificate.

## 7. Covid-19 policy response cost-effectiveness assessment

We identified five models of Covid-19 policy response characterised by different policy approaches and policy stringency, which led to different health, socio-economic and environmental effects. Those models better explain the variation in terms of policy relevance assessed through the matrix of relevance. Starting from those results, we assess the cost-effectiveness of each national policy model by identifying and attributing monetary values to costs and effects generated by policy responses in each country. The identification and evaluation of direct policies' costs and effects take into consideration two years of implementation. Potential further effects generated by policies after this time span are not considered in the analysis. For instance, public expenditure to support families and businesses during the outbreak is here considered a social cost, even if it might generate positive effects in later years, as suggested by the literature (Pianta, Lucchese and Nascia, 2021). Finally, we compared costs and effects of each national policy model to identify which country model has been more effective in coping with Covid-19 pandemic[36].

[35] These policy models may also fit to other countries, beyond the five cases analysed.

[36] A policy model is cost-effective when overall monetized effects are higher than overall monetized costs.

Based on data availability and considering the time span of our analysis – from 2020 to 2021 -, we attributed monetary values to two cost factors that represent direct public costs associated with the implementation of policy responses in the five countries:

- National cost for economic support to companies and households. Although this government expenditure is expected to generate positive effects on national society and economies in the long period (Devereux, 2021), we consider it as a temporary cost within the analysis (see e.g. Pianta, Lucchese and Nascia, 2021). National cost for economic support to companies and households is measured in billion euros.
- Health policies costs[37], including costs for Covid-19 vaccination campaigns (Covid-19 vaccines, investments in vaccines research programmes and costs related to vaccines delivery and administration, Debrabant et al., 2021; Martonosi et al., 2021); investments in testing and contact tracing, purchase of face masks (House of Commons Public Accounts Committee UK Government, 2021). Health policies costs are measured in billion euros.

Based on data availability and considering the time span of our analysis – from 2020 to 2021 -, we attributed monetary values to three policy effects:

- GDP recovery generated by economic support policies undertaken at the national level to cope with the negative impact of containment policies, and health policies implementation (Kaplan et al., 2020; OECD, 2020d; Pianta, Lucchese and Nascia, 2021). Indeed, GDP recovery in 2021 is the result of different health and economic support policies adoption, which allowed national governments to impose less strict lockdowns. GDP recovery is calculated as the variation of GDP in 2021 compared to 2020, as a proxy to evaluate the direct impact of Covid-19 policy responses on economic activities. A comparative analysis between pre-pandemic GDP levels (2019) and after pandemic data (2021) might not represent the effectiveness of policy responses in dealing with the temporary economic shock experimented in 2020. GDP recovery is measured in billion euros.
- Reduction of CO2 emissions, as a proxy for co-benefits generated by containment policies (Schneider et al., 2022; US EPA, 2014). The (temporary) reduction of CO2 emissions improves air quality and has positive impacts on human health (Crippa et al., 2020). It has been evaluated by using the market price of the European Union Emissions Trading Scheme (ETS), expressed in euros per one Mt CO2 (EEX, 2021). We calculated the yearly average of ETS market values of CO2 emissions across two years[38]. It is measured in billion euros.
- Covid-19 deaths averted through Covid-19 vaccines which shows the effectiveness of vaccination campaigns (Hammitt, 2020; Meslé et al., 2021; Viscusi, 2020). In our cost-effectiveness analysis, we were not able to monetize the number of Covid-19 deaths averted through the adoption of other health policies (different from vaccination campaigns). For instance, Covid-19 deaths averted by lockdown measures[39] are hard to determine due to the combined presence of several health policies and other containment ones. Covid-19 deaths

[37] Subject to data availability.

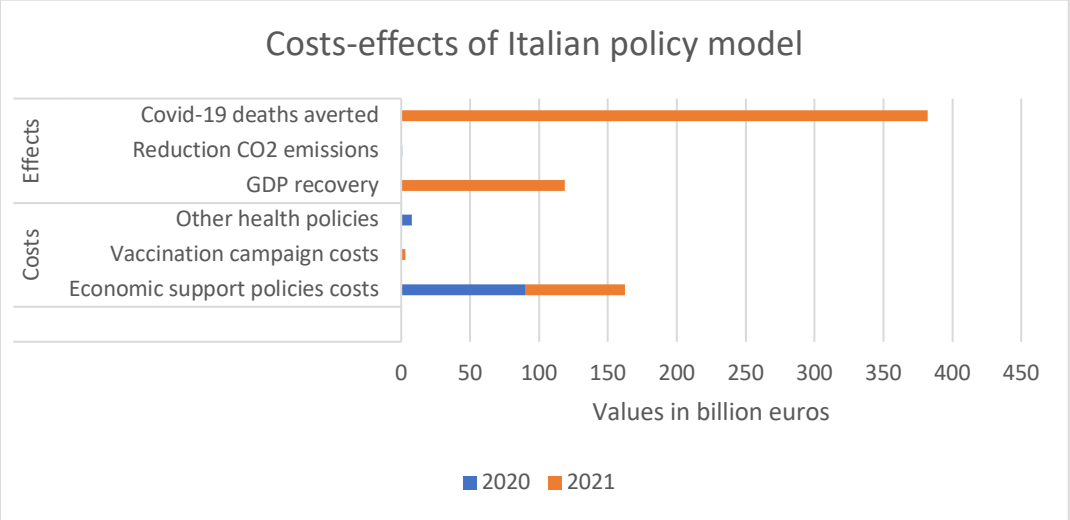
[38] 2019-2020.

[39] Moreover, it is too difficult to know how many people would have died without containment policies (Kaplan et al., 2020).

averted are monetised using the Value of Statistical Life[40] (VSL). The VSL is the local trade-off rate between fatality risk and money (Viscusi, 2020) and it is expressed in billion euros[41].

Costs and effects generated by policy response models from 2020 to 2021 have been calculated based on data coming from 1. international datasets for GDP (OECD Economic Outlook Database), CO2 emissions (ETS for price per Mt CO2) and Covid-19 deaths averted (World Health Organization Database); 2. national datasets for public expenditures, and healthcare costs (investments in vaccination campaign, testing & contact tracing, purchase of face masks). Per each national policy model, costs and effects generated between 2020 and 2021 have been evaluated and compared.

Figure 26 Costs and effects (billion euros) of the Italian policy response model, 2020 - 2021



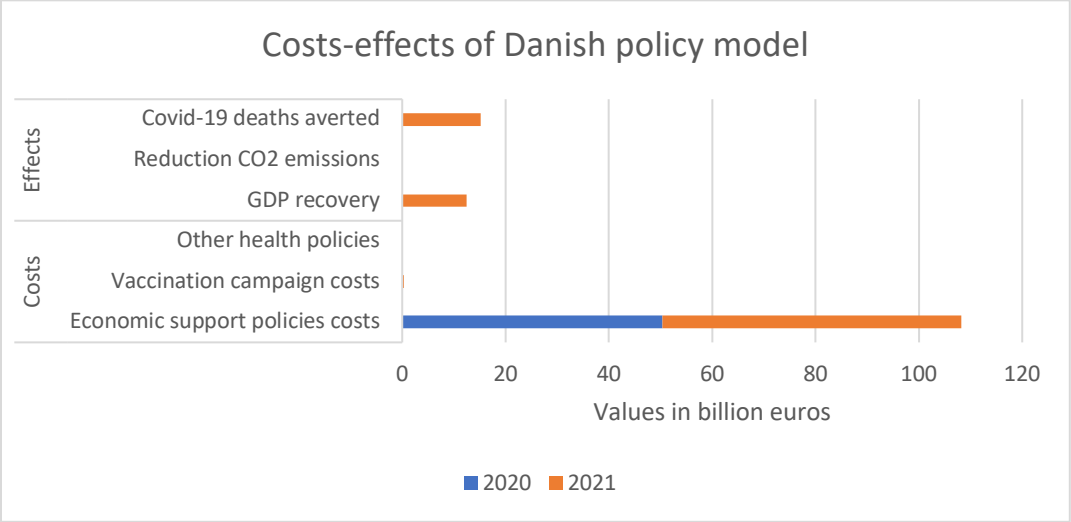

Source: GREEN elaboration.

In the Italian model, the majority of costs (around 93%) relate to supporting family incomes and businesses in 2020 and 2021 (162.3 billion euros). Concerning health policies: 3.1 billion euros have been spent on the vaccination campaign (2021); 7.8 billion euros to finance other health policies such as testing & contact tracing, and the purchase of face masks. Regarding the effects generated by the Italian policy model, the GDP recovery represents a highly relevant effect in 2021, with a 23.6% increase compared to 2020. This reflects the relevance of economic support policies and the consequences of health policies (i.e., vaccination), which reduced the need for strict containment policies. A reduction of CO2 emissions in 2020 (-30Mt of CO2 emissions compared to 2019, corresponding to 0.739 billion euros) emerges as co-benefits generated by containment policies. Evaluating the effectiveness of health policies, – i.e. the vaccination campaign – we estimate 53,947 Covid-19 deaths averted through vaccination, corresponding to 381.93 billion euros (76.2% of total social effects).

[40] VSL is the Value of a Statistical Life. VSL measures how much the average citizen is willing to pay for a reduction in the probability of death (Greenstone and Nigam, 2020). It is one statistical life, which is a reduction in mortality rates equivalent to save one life on average. In other words, VSL is the individual's local money-mortality risk trade-off value. The pertinent valuation concept is the value of small changes in mortality risk, not the value attached to identified lives (Viscusi, 2020).

[41] To estimate the number of deaths averted by vaccination, we remove COVID-19 deaths among vaccinated adults and Covid-19 deaths below 20 years old from the total amount of Covid-19 deaths in each country. According to the literature (CDC, 2021a; Grange et al., 2021), we assumed 4% of deaths were among vaccinated people, not considering Covid-19 deaths below 20 years old. We use CDC 2021b studies of vaccine effectiveness against death to estimate Covid-19 deaths averted. CDC 2021b estimates vaccine effectiveness against death at around 91%.

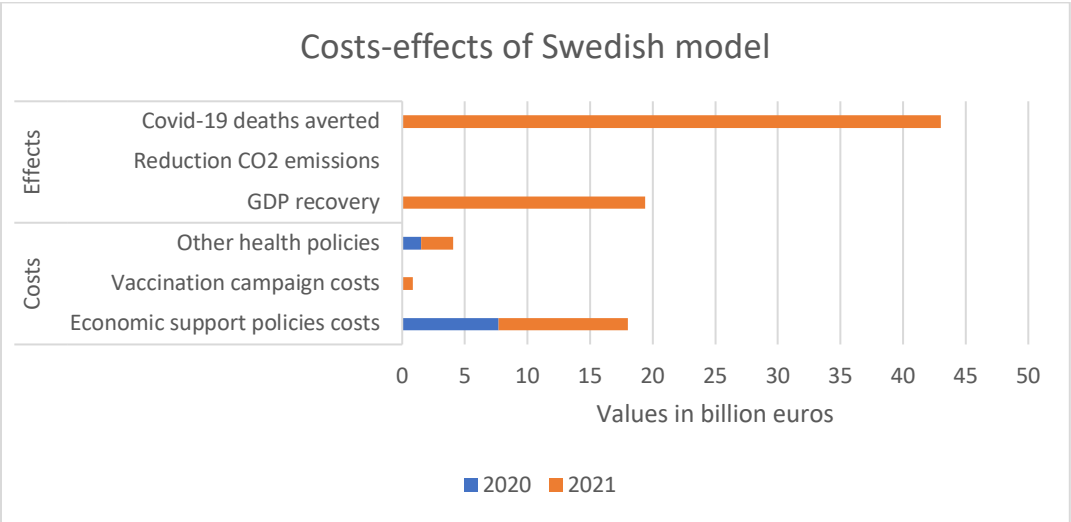
Figure 27 Costs and effects (billion euros) of the Danish policy model, 2020 - 2021




Source: GREEN elaboration.

The Danish model shows that 108.25 billion euros (99% of total social costs in Denmark) have been invested by the Danish government in supporting households and companies. The costs of the vaccination campaign correspond to 0.32 billion euros. Analysing the policy model effects, the Danish model reports a GDP recovery of 12.5 billion euros in 2021 (45% of the overall effects), representing the mixed effect of economic support policies and vaccination campaigns. CO2 emissions reduction (-2,8 Mt of CO2 emissions in 2020 compared to 2019, 0.07 billion euros) has been identified as a co-benefit of containment policies. Regarding health policies (vaccination campaign), 1,615 Covid-19 deaths have been averted. The related monetary value is 15.2 billion euros (54.7% of total Denmark's effects).

Figure 28 Costs and effects (billion euros) of the Swedish policy model, 2020 - 2021

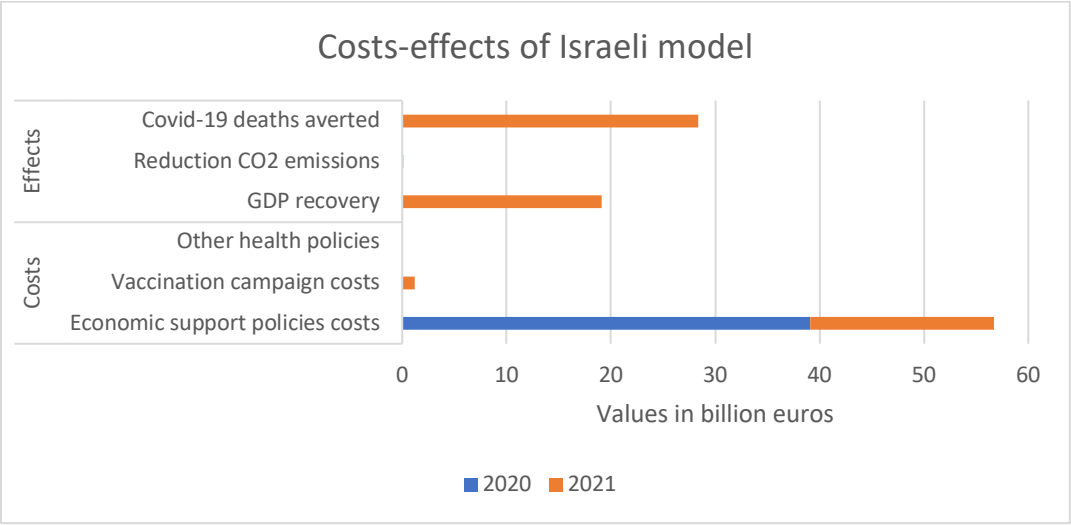



Source: GREEN elaboration.

18 billion euros (78.5% of total costs in Sweden) have been invested by the Swedish government to support households and companies. The costs of the vaccination campaign correspond to 0.85 billion

euros, whereas other health policies – beyond the vaccination campaign – cost 4.1 billion euros in Sweden (around 17% of total costs). Looking at the effects generated, the Swedish model reports a GDP recovery of 19.4 billion euros in 2021 (31.1% of its total effects). A CO2 emissions reduction of 1,51 Mt (0.04 billion euros) has been identified as a consequence of containment policies adopted in 2020. Regarding health policies (vaccination campaign), 4,618 Covid-19 deaths have been averted. The related overall monetary value is 43 billion euros (68.9% of total Sweden's effects).

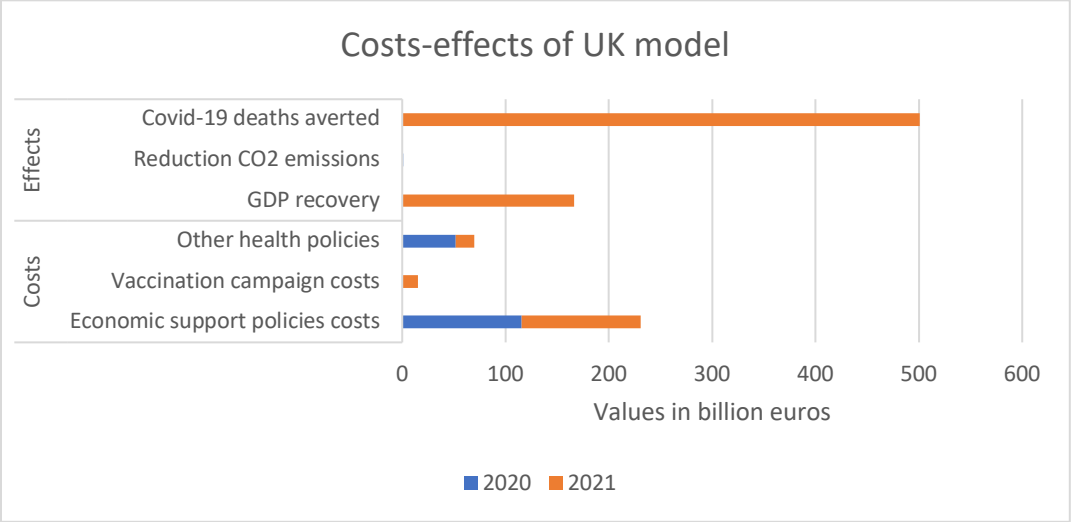
Figure 29 Costs and effects (billion euros) of the Israeli policy model, 2020 - 2021




Source: GREEN elaboration.

The Israeli model reports heavy investments in supporting the national economy, with 56.73 billion euros (around 97.9% of total costs) invested in economic support policies. The remaining 2.1% refers to the vaccination campaign (1.2 billion euros). Analysing the effects, the Israeli model shows a GDP recovery of 19.1 billion euros in 2021, representing 40.1% of the total effects generated. This represents the positive effects of economic support policies mixed with an early and well-organized vaccination campaign. An environmental co-benefit of 0.101 billion euros refers to CO2 emissions reduction in 2020. Moreover, Covid-19 deaths averted through Covid-19 vaccines is 4,120, corresponding to an overall monetary value of 28.39 billion euros (59.7% of total effects).

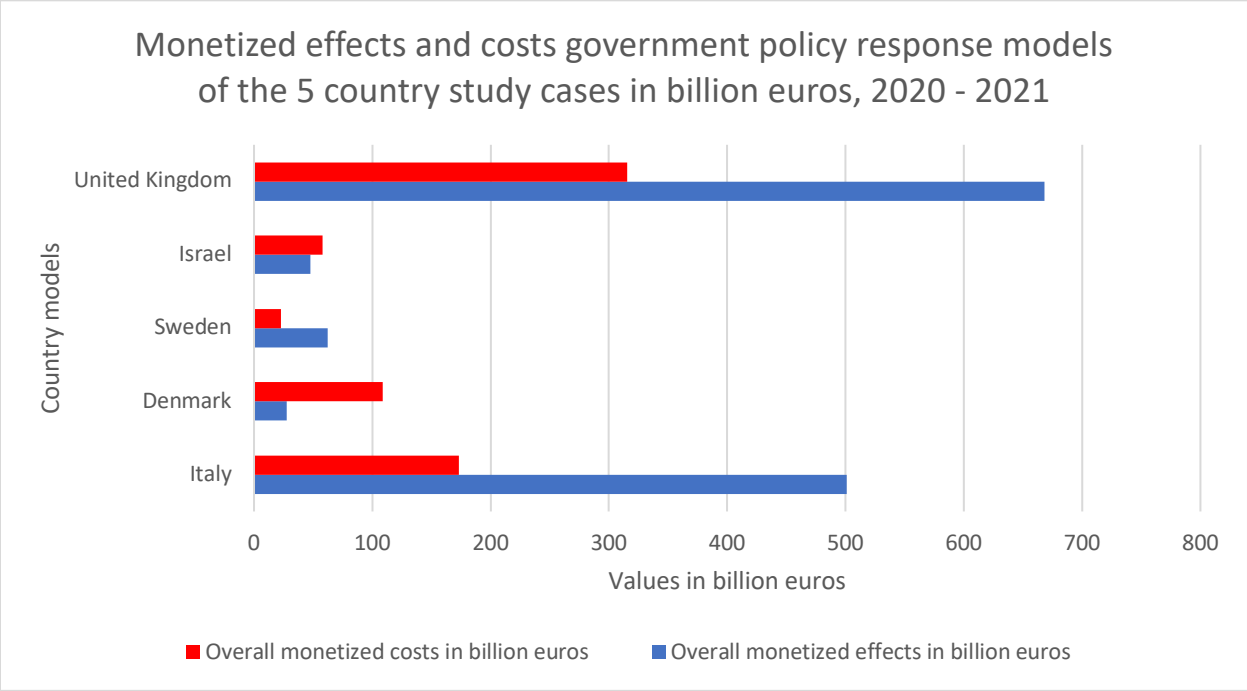
Figure 30 Costs and effects (billion euros) of the UK policy model, 2020 - 2021




Source: GREEN elaboration.

In the UK model, 230.6 billion euros – representing 73% of total costs - have been invested in economic supporting policies. The remaining 27% refers to health policies costs, including 15.4 billion euros for Covid-19 vaccination campaign and 69.65 billion euros for other health policies, i.e. testing & contact tracing, and the purchase of face masks. The UK government strongly supported and invested in R&D linked to vaccine development. Huge funding came to Oxford University in collaboration with AstraZeneca, the UK-based pharmaceutical company, for the commercialization and manufacturing of their vaccine which was used all over Europe. Looking at the effects, the UK model reports a GDP recovery of 166.3 billion euros in 2021 (24.9% of total effects), as a mixed consequence of economic support policies and containment policies. The United Kingdom shows a reduction of CO2 emissions of 36 Mt in 2020, corresponding to 0.91 billion euros. Furthermore, the estimated number of Covid-19 deaths averted is 64,083, with a monetary value of 501.05 billion euros (75% of total effects). Figure 31 shows the comparison between all costs and effects generated by national policy models in 2020 and 2021.

Figure 31 Cost-effectiveness analysis models of policy responses, 2020 - 2021




Source: GREEN elaboration.

The Italian model shows a net positive effect of 327.97 billion euros, with monetized effects (501.2 billion euros) overcoming monetized costs (173.2 billion euros). Although Italy reported high economic losses, the high stringency and effectiveness of the Covid-19 vaccination campaign and other health measures have been crucial to achieving a positive balance between costs and effects.

The Danish model shows higher overall costs (108.6 billion euros) than effects (27.8 billion euros) generated by policy responses, with a net social cost of 80.8 billion euros. This loss is mostly connected to high economic support policies costs (99% of total costs). Economic support policies have probably been too high if compared to temporary needs, considering the soft containment policies adopted by the Danish government. In long term, this result might change, proving a restored balance between costs and effects. However, the analysis takes into consideration only two years of policies responses' effects and costs.

The Swedish model shows a net positive effect of 39.5 billion euros. 78.5% of total costs in Sweden refer to economic support policies. However, a wide positive effect is generated by health policies, like vaccinations, which show high efficacy in terms of Covid-19 deaths averted, corresponding to 43 billion euros. Although the Swedish and Danish models are similar in terms of policy approach, the models show different levels of effectiveness. According to the results, this difference is linked to the intensity of economic support policies (99% of overall costs in Denmark and 78.5% in Sweden), and the lower investments in terms of health policies in Denmark, such as contact tracing measures. However, the analysis considers only two years of policy models' costs and effects. Extending the analysis period, the Danish model might show higher positive social effects, considering the high public expenditure.

The Israeli model shows higher costs (57.9 billion euros) than effects (47.6 billion euros) generated by Covid-19 policy responses. The strict and well-organised vaccination campaign in Israel generated an estimated effect of 28.39 billion euros, reflecting 4,120 Covid-19 deaths averted. However, this effect, combined with other positive effects concerning GDP recovery in 2021 and CO2 emissions reduction, has been not enough to recover social costs concerning economic support policies for families and companies.

The UK model generates a net positive effect of 352.6 billion euros. The overall effects of Covid-19 policy responses (668.2 billion euros) overcome overall costs (315.6 billion euros). The major source of costs regards economic support policies that account for more than 73% of total costs. Nonetheless, positive effects concerning GDP recovery in 2021 and the Covid-19 deaths averted through vaccines (501.1 billion euros) have been effective in covering the wide social costs.

Italy, Sweden and the United Kingdom are the countries where the overall effects overcome costs. Nevertheless, the percentage gap between social effects and costs is quite different among countries. Italy and the United Kingdom have a percentage gap between effects and costs of 65.4% in Italy and 52.8% in the UK, showing a high level of cost-effectiveness of the policy models. Sweden has the largest percentage gap after Italy, i.e. of 63.3%, which represents the high effectiveness of this model, even though in a low-density country that has been less hit by the pandemic compared to Italy and the United Kingdom. Conversely, Denmark and Israel report a negative balance, i.e. the overall costs overcome effects. According to the results, the percentage gap is 17.8% in Israel and 74.4% in Denmark, showing the low effectiveness of those two models.

Regarding the GDP effectiveness factor, Italy and the United Kingdom show the highest GDP recovery in 2021 compared to 2020, which does not assure the return to pre-pandemic levels. When compared to pre-pandemic GDP levels in 2019, Italy and the United Kingdom show a slower GDP recovery than the other countries in 2021. Indeed, the GDP in Italy and the UK GDP decreased by 5.3% and 3.4% in 2021 compared to 2019. Conversely, Israel, Sweden and Denmark show a GDP recovery of, respectively, 4.1%, 1.3% and 1.8% in 2021 compared to 2019. This indicates the high impact of containment policies in Italy and the United Kingdom and confirms the effectiveness of policy responses in limiting the damages.

## 8. Conclusion

The study aimed at assessing the cost-effectiveness of Covid-19 policy responses in five countries: Denmark, Italy, Israel, Sweden and the United Kingdom. Covid-19 policy responses are crucial to managing short-term trade-offs between minimizing health risks and economic losses. We divided Covid-19 policy responses into three groups: containment policies, economic support policies and health policies. In order to understand the efficacy of policy responses we analysed trends and variations of economic, social, health and environmental variables within two years (2020 and 2021), then we developed statistical relationships between socioeconomic, health and environmental impacts and policy responses. Finally, we set up a matrix of relevance aimed at identifying the relevance of statistical relationships analysed in the five study cases. Statistical relationships are relevant when direct relationships between policies and socioeconomic, health and environmental impacts emerged. In general, stricter containment policies show high relevance in generating economic impacts (e.g. GDP loss), and in reducing health risks. Moreover, containment policies were relevant in dropping CO2 emissions in the five countries, particularly during the first wave of Covid-19 outbreak, when

lockdown measures were implemented extensively. Economic support policies show a limited relevance in minimizing the negative impacts of containment policies only where economic support was more generous. Health policies show high relevance in containing the impact on human health. The vaccination campaign is the most relevant health measure, while the contact tracing measure shows high relevance only when combined with high investments in digital infrastructures and local point-of-care, like in Israel and the United Kingdom. However, it is hard to disaggregate impacts coming from each policy and measure since those are never implemented alone and rebound effects might compromise the identification of direct impacts. Assessing the effectiveness of single policies and measures can generate double counting of costs and effects, suggesting the need to look at national approaches or models to cope with Covid-19 pandemic. Based on countries' policy approaches, we identify five models of Covid-19 policy responses. Each national policy model represents a policy mix or package to face the pandemic, and brings different impacts and effects. Italian model is characterised by strict containment policies, moderate economic support policies, and strict vaccination campaign. The Danish Swedish models show many similarities. Those models are characterised by no or very weak lockdowns, strong economic support policies, and moderate health policies (i.e. vaccination campaigns). Israeli model is characterised by moderate lockdown, strong economic support policies and high attention to the vaccination campaign. The UK model is characterised by strict and short lockdowns, strong economic support policies and strong health policies, i.e. vaccination campaigns, testing and contact tracing. The cost-effectiveness assessment has been developed for the five national policy models within two years (2020 – 2021). We chose two policy cost factors and three policy effects. Policy costs analysed are: costs of economic support policies; costs of health policies, i.e. vaccination campaigns, testing & contact tracing, and purchase of face masks. Policy effects investigated are: reduction of CO2 emissions, which is an environmental co-benefit; GDP recovery, a proxy for evaluating the effectiveness of economic support policies and health and containment policies; Covid-19 deaths averted through Covid-19 vaccines. We attributed monetary values to policy costs and effects combining data from international and national datasets. The cost-effectiveness analysis shows high effectiveness for the Italian model. The highest policy effect regards Covid-19 deaths averted through Covid-19 vaccines that – along with GDP recovery in 2021 – overcome costs related to economic support policies. Likewise, the UK model shows total effects higher than total costs. The main cost refers to public expenditures for economic support policies. High investments (costs) have been devoted also to testing & contact tracing aimed at flattening the pandemic curve. Nevertheless, policy effects related to GDP recovery in 2021 and Covid-19 deaths averted through vaccines have been effective in covering the wide costs. The Swedish model also achieves high policy effectiveness, with effects widely overcoming costs for economic support policies. Although the Sweden model is cost-effective, Sweden has a lower population density compared to other countries and it has been less hit by Covid-19 pandemic. The Danish and Israeli models show negative cost-effectiveness; overall monetized costs overcome overall monetized effects. Although the Danish model is similar to the Swedish one, Denmark shows too high expenditures on economic support policies if compared to contextual needs, considering the soft containment policies adopted by the Danish government. In the long term, this result might change, bringing a restored balance between costs and effects. However, the analysis takes into consideration only two years of policies responses' effects and costs. The main source of policy effect in the Israeli model relates to Covid-19 deaths averted through Covid-19 vaccines, given the early and well-organised vaccination campaign. This monetized policy effect – along with other effects on GDP recovery in 2021 and CO2 emissions reduction – was not enough to cover the high costs related to economic support policies. Likewise, in the Danish model, economic support has been extremely high compared to the moderate containment policies undertaken by the Israeli government, i.e. relatively weak lockdown.

In conclusion, the cost-effectiveness assessment shows high effectiveness in facing Covid-19 outbreak for the Italian and the UK models, considering the economic recovery after the high drop in terms of GDP and the severity of Covid-19 pandemic in terms of cases and deaths in these two countries. Those models are characterized by temporary strict lockdowns, moderate economic support and strict health policies in terms of face covering, testing, contact tracing and vaccination campaigns. This result considers only two years of costs and effects generated by national policy models. In long term, less cost-effective models might produce unexpected positive social effects due to the high public investments in the welfare sectors.

However, the study faced some limitations. Firstly, Covid-19 deaths averted through the implementation of containment policies and other health policies were not considered due to the difficulties in disaggregating direct effects of complex and mixed policy responses. For instance, it is not an easy task to determine how many Covid-19 deaths have been averted through lockdowns, testing & contact tracing, face coverings, etc. Secondly, the lack of availability of comparable data about policies costs and effects for all countries makes it challenging to explore all impacts generated by different types of policies. Indeed, we considered only policies and measures implemented by all countries to assure comparability. Thirdly, our analysis assesses GDP recovery in 2021 compared to 2020 as a proxy to evaluate the effects of containment, economic and health policies beyond vaccination campaigns. However, we didn't calculate the averted GDP loss by carrying out a counterfactual analysis aimed at estimating the yearly GDP variation without the introduction of policy responses. Further analysis considering those limitations will be carried on in the following months by performing a regression analysis at a world scale which allows the assessment of wider data.

## References


Agresti, A. (2018). Statistical methods for the social sciences. Fifth edition. Pearson Education Limited.

Aleta, A., Martin-Corral, D. et al. (2020). Modelling the impact of testing, contact tracing and household quarantine on second waves of Covid-19. Nature Human Behavior, Vol. 4; pp. 964-971.

Altiparmakis, A., Bojar, A., Brouard, S. et al. (2021). Pandemic politics: policy evaluations of government responses to Covid-19. West European Politics, Vol. 44, No. 5-6; pp. 1159-1179.

Altshuler, T. S. and Hershkovitz, R. A. (2020). Digital contact tracing and the Coronavirus: Israeli and comparative perspectives. Governance, Foreign Policy at Brookings.

Andersen, T. (2021). Economic policy during and lessons for the future – The case of Denmark. CESifo Forume, Vol. 22; pp. 17-21. Available at: https://www.cesifo.org/DocDL/CESifo-Forum-2021-6-andersen-restart-after-covid-19-november.pdf

Andersen, T. M., Schroder, P. J. H. and Svarer, M. (2020). Designing reopening strategies in the aftermath of Covid-19 lockdowns: some principles with an application to Denmark. IZA Policy Paper No. 158. IZA, Institute of Labor Economics. Initiated by Deutsche Post Foundation.

Anderson, R. M., Heesterbeek, H., Klinkenberg, D. and Hollingsworth, D. (2020). How will country-based mitigation measures influence the course of the Covid-19 epidemic? Lancet (London, England), Vol. 395, No. 10228; pp. 931-934.

Antonini, M., Eid, M. A., Falkenbach, M., Rosenbluth, S. T. (2021). An analysis of the Covid-19 vaccination campaigns in France, Israel, Italy and Spain and their impact on health and economic outcomes. Health Policy and Technology,

Aruga, K., Islam, M. M. and Jannat, A. (2021). Does staying at home during the Covid-19 pandemic help reduce CO2 emissions? Sustainability, Vol. 13, No. 15.

Barda, N., Dagan, N. et al. (2021). Effectiveness of a third dose of the BNT162b2 mRNA Covid-19 vaccine for preventing severe outcomes in Israel: an observational study. The Lancet

Barro, R. J., Ursua, J. F. and Weng, J. (2020). The Coronavirus and the great influenza pandemic: lessons from the "Spanish Flu" for the Coronavirus' potential effects on mortality and economic activity. Working Paper No. 26866, National Bureau of Economic Research.

Becker, T., Roine, J. and Stromberg, S. (2021). The "Swedish model" in the Covid-19 pandemic. BSR Policy Briefing 9/2021. Available at: https://www.centrumbalticum.org/files/5078/BSR_Policy_Briefing_9_2021.pdf

Bellomo, N., Binghan, R., Chaplain, M. K., Dosi, G., Forni, G., Knopoff, D. A., Lowengrub, J., Twarock, R. and Virgillito, M. E. (2020). A multi-scale model of virus pandemic: heterogeneous interactive entities in a globally connected world. Mathematical Models and Methods in Applied Sciences, Vol. 30, No. 8; pp. 1591-1651.

Bental, B. and Shami, L. (2020). The impact of the Coronavirus on the economy of Israel: an overview. Taub Center for Social Policy Studies in Israel. Jerusalem, December 2020. Available at: https://www.taubcenter.org.il/wp-content/uploads/2021/01/impactofcoronavirusontheeconomyofisraeloverview.pdf

Berawi, M. A., Suwartha, N., Kusrini, E. et al. (2020). Tackling the Covid-19 pandemic: managing the cause, spread, and impact. International Journal of Technology, Vol. 11, No. 2; pp. 209-214.

Birenbaum-Carmeli, D. and Chassida, J. (2021). Health and socio-demographic implications of the Covid-19 second pandemic wave in Israel, compared with the first wave. International Journal for Equity in Health, Vol. 20, No. 154.

Bleichrodt, H. and Quiggin, J. (1999). Life-cycle preferences over consumption and health: when is cost-effectiveness analysis equivalent to cost-benefit analysis? Journal of Health Economics, Vol. 18, No. 6; pp. 681-708.

Boone, L. and Ladreit, C. (2021). Fear of COVID and non-pharmaceutical interventions: an analysis of their economic impact among 29 advanced OECD countries. Covid Economics, Vol. 73; pp. 1-40.

Bricco, J., Misch, F., Solovyeva, A. and Sakr, K. (2020). What are the economic effects of pandemic containment policies? Evidence from Sweden. International Monetary Fund Working Paper No. 191.

Brocard, E., Antoine, P., Mélihan-Cheinin, P., & Rusch, E. (2021). COVID-19's impact on home health services, caregivers and patients: lessons from the French experience. The Lancet regional health. Europe, 8, 100197. https://doi.org/10.1016/j.lanepe.2021.100197

Brooks, J. T., Beezhold, D. H., Noti, J. D. et al. (2021). Maximizing fit for cloth and medical procedure masks to improve performance and reduce SARS-CoV-2 transmission and exposure. Morbidity and Mortality Weekly Report, Vol. 70, No. 7; pp. 254-257.

Buechler, E., Powell, S., Sun, T., Astier, N. et al. (2022). Global changes in electricity consumption during Covid-19. Science, Vol. 25, No. 1.

Byford, S., Torgerson, D. J. and Raftery, J. (2000). Economic note: cost of illness studies. British Medical Journal, Vol. 320, No. 7245; p. 1335.

Callen, T. (2007). PPP versus the market: which weight matters? Finance and Development, Vol. 44, No. 1. A quarterly magazine of the International Monetary Fund (IMF).

Camera dei Deputati – Servizio Studi XVIII Legislatura (2022). Misure sanitarie per fronteggiare l'emergenza coronavirus. Studi – Affari Sociali, Welfare. Available at: https://www.camera.it/temiap/documentazione/temi/pdf/1214749.pdf?_1645117755880

Capano, G. (2020). Policy design and state capacity in the Covid-19 emergency in Italy: if you are not prepared for the (un)expected, you can be only what you already are. Policy and Society, Vol. 39, No. 3; pp. 326-344.

Carlsson-Szlezak, P., Reeves, M. and Swartz, P. (2020). What Coronavirus could mean for the global economy. Harvard Business Review, Vol. 3.

Casella, G. and Berger, R. L. (2002). Statistical Inference. Second Edition. Duxbury Advanced Series.

Centre for Disease Control and Prevention (CDC) (2021a). Covid-19 incidence and death rates among unvaccinated and fully vaccinated adults with and without booster doses during periods of Delta and Omicron variants emergence – 25 U.S. Jurisdictions, April 4th – December 25th, 2021. Morbidity and Mortality Weekly Report, Vol. 71, No. 4; pp. 132-138. Available at: https://www.cdc.gov/mmwr/volumes/71/wr/mm7104e2.htm

CDC (2021b). Monitoring incidence of Covid-19 cases, hospitalisation, and deaths, by vaccination status – 13 U.S. Jurisdictions, April 4th – July 17th, 2021. Morbidity and Mortality Weekly Report, Vol. 70, No. 37; pp. 1284-1290.

CDC (2020). COVID-19 Provisional Counts - Weekly Updates by Select Demographic and Geographic Characteristics. National Center for Health Statistics. Available online at: https://www.cdc.gov/nchs/nvss/vsrr/covid_weekly/index.htm

Chinazzi, M., Davis, J. T., Ajelli, M. et al. (2020). The effect of travel restrictions on the spread of the 2019 novel coronavirus (Covid-19) outbreak. Science, Vol. 368; pp. 395-400.

Cho, S-W (2020). Quantifying the impact of nonpharmaceutical interventions during the Covid-19 outbreak: the case of Sweden. The Econometrics Journal, Vol. 23; pp. 323-344.

Clapp, P. W., Sickbert-Bennett, E., Samet, J. M., Berntsen, J et al. (2020). Evaluation of Cloth masks and modified procedure masks as personal protective equipment for the public during the Covid-19 pandemic. JAMA International Medicine, Vol. 181, No. 4; pp. 463-469.

Collivignarelli, M.C, Abbà, A., Bertanza, G., Pedrazzani, R., et al (2020). Lockdown for CoViD-2019 in Milan: What are the effects on air quality? Science of The Total Environment, Volume 732, 139280, https://doi.org/10.1016/j.scitotenv.2020.139280.

Conyon, M. J., He, L. and Thomsen, S. (2020). Lockdowns and Covid-19 deaths in Scandinavia. Covid Economics, No. 26; pp. 17-42.

Coveri, A., Cozza, C., Nascia, L. and Zanfei, A. (2020). Supply chain contagion and the role of industrial policy. Journal of Industrial and Business Economics, Vol. 47; pp. 467-482.

Crippa, M., Guizzardi, D., Muntean, M., Schaaf, E. et al. (2020). Fossil CO2 emissions of all world countries. 2020 Report, EUR 30358 EN, Publications Office of the European Union, Luxembourg, 2020.

CRS (Congressional Research Service) (2021a). Global Economic Effects of Covid-19. Updated April 26, 2021. Available at: https://crsreports.congress.gov/product/details?prodcode=R46270

CRS (Congressional Research Service) (2021b). Global Economic Effects of Covid-19. Updated October 4, 2021. Available at: https://crsreports.congress.gov/product/details?prodcode=R46270

Cylus, J., Panteli, D. and van Ginneken, E. (2021). Who should be vaccinated first? Comparing vaccine prioritization strategies in Israel and European countries using the Covid-19 Health System Response Monitor. Israel Journal of Health Policy Research, Vol. 10, No. 16.

Danhieux, K., Buffel, V., Pairon, A. et al. (2020). The impact of COVID-19 on chronic care according to providers: a qualitative study among primary care practices in Belgium. BMC Fam Pract 21, 255 (2020). https://doi.org/10.1186/s12875-020-01326-3

Daoust, J. F. (2020). Elderly people and responses to Covid-19 in 27 countries. Plos ONE, Vol. 15, No. 7; e0235590.

Dash, D. P. and Sethi, N. (2022). Pandemics, lockdown and economic growth: a region-specific perspective on COVID-19. Bulletin of Monetary Economics and Banking, Vol. 25; pp. 43-60.

Deb, P., Furceri, D., Jimenez, D., Kothari, S., Ostry, J. D. and Nour, T. (2021). Determinants of Covid-19 vaccine rollouts and their effects on health outcomes. IMF Working Paper No. 2021/247. Available at: https://www.imf.org/en/Publications/WP/Issues/2021/10/19/Determinants-of-COVID-19-Vaccine-Rollouts-and-Their-Effects-on-Health-Outcomes-494711

Deb, P., Furceri, D., Jimenez, D., Kothari, S., Ostry, J. D. and Tawk, N. (2022). The effects of Covid-19 vaccines on economic activity. Swiss Journal of Economics and Statistics, Vol. 158, No. 3.

Deb, P., Furceri, D., Ostry, J. D. and Tawk, N. (2020). The economic effects of Covid-19 containment measures. International Monetary Fund Working Paper No. 158.

Debrabant, K., Gronbaek, L. and Kronborg, C. (2021). The cost-effectiveness of a Covid-19 vaccine in a Danish context. Clinical Drug Investigation, Vol. 41; pp. 975-988.

Demirguc-Kunt, A., Lokshin, M., and Torre, I. (2020). The sooner, the better: the early economic impact of non-pharmaceutical interventions during the COVID-19 pandemic. Economics of Transition and Institutional Change, Vol. 29, No. 4; pp. 551-573.

Devereux, M. P., Guceri, I., Simmler, M. and Tam, E. H. F. (2020). Discretionary fiscal responses to the Covid-19 pandemic. Oxford Review of Economic Policy, Vol. 36, No. 1; pp. S225-S241.

De Wolff, T., Pfluger, D., Rehme, M., Heuer, J. and Bittner, M.-I. (2020). Evaluation of pool-based testing approaches to enable population-wide screening for Covid-19. Plos One, Vol. 15, No. 12.

Diop, B. Z., Ngom, M. and Pougué, B. C. et al. (2020). The relatively young and rural population may limit the spread and severity of Covid-19 in Africa: a modelling study. British Medical Journal Global Health, Vol. 5.

Donaldson, C. (1998). The (near) equivalence between cost-effectiveness analysis and cost-benefit analysis: fact or fallacy? Pharmacoeconomics, Vol. 13; pp. 389-396.

Dosi, G., Fanti, L. and Virgillito, M. E. (2020). Unequal societies in usual times, unjust societies in pandemic ones. Journal of Industrial and Business Economics, Vol. 47; pp. 371-389.

Egert, B., Guillemette, Y., Murtin, F. and Turner, D. (2021). Walking the tightrope: avoiding a lockdown while containing the virus. Covid Economics, Vol. 64.

Emmerling, J., Furceri, D., Monteiro, F. L., Pizzuto, P. and Tavoni, M. (2021). Will the economic impact of Covid-19 persist? Prognosis from 21st century pandemics. International Monetary Fund Working Paper No. 119.

Errett, N. A., Sauer, L. M. and Rutkow, L. (2020). An integrative review of the limited evidence on international travel bans as an emerging infectious disease disaster control measure. Journal of Emergency Management, Vol. 18, No. 1; pp. 7-14.

Esen, O. and Bayrak, M. (2017). Does more energy consumption support economic growth in net energy-importing countries? Journal of Economics, Finance and Administrative Science, Vol. 22, No. 42.

Fernandes, N. (2020). Economic effects of Coronavirus outbreak (Covid-19) on the world economy. IESE Business School Working Paper No. WP-1240-E. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3557504

Fetzer, T. and Graeber, T. (2021). Measuring the scientific effectiveness of contact tracing: evidence from a natural experiment. Proceedings of the National Academy of Sciences of the United States of America (PNAS), Vol. 118, No. 33.

Fletcher, M. (2020). Government's income support responses to the Covid-19 pandemic. Policy Quarterly, Vol. 16, No. 3; pp. 73-78.

Furceri, D., Loungani, P., Ostry, J. D. and Pizzuto, P. (2021). The rise in inequality after pandemics: can fiscal support play a mitigating role? Industrial and Corporate Change, Vol. 30, No. 2; pp. 445-457.

Gavi, the Vaccine Alliance. The COVAX facility: Interim Distribution Forecast, 3rd February 2021. Available at: https://www.gavi.org/sites/default/files/covid/covax/COVAX-Interim-Distribution-Forecast.pdf

Ghosh, I. (2020). The road to recovery: which economies are reopening? Available at: https://www.visualcapitalist.com/the-road-to-recovery-which-economies-are-reopening-covid-19/

Ghosh, S. K. and Ghosh, B. K. (2020). Fossil fuel consumption trend and global warming scenario: energy overview. Global Journal of Engineering Sciences, Vol. 5, No. 2.

Gold, M. R., Siegel, J. E., Russell, L. B. and Weinstein, M. C. (1996). Cost-effectiveness in Health and Medicine. Oxford University Press.

Gori, T., Lelieveld, J. and Munzel, T. (2020). Perspective: cardiovascular disease and the Covid-19 pandemic. Basic Research in Cardiology, Vol. 115, No. 32.

Granella, F., Reis, L. A., Bosetti, V. and Tavoni, M. (2020). Covid-19 lockdown only partially alleviates health impacts of air pollution in Northern Italy. Environmental Research Letters, Vol. 16, No. 3.

Grange et al. (2021). Characteristics and risk of Covid-19 related death in fully vaccinated people in Scotland. The Lancet, Vol. 398, No. 10313; pp. 1799-1800.

Greenhalg, T., Jimenez, J. L., Prather, K. A., Tufekci, Z., Fisman, D. and Schooley, R. (2021). Ten scientific reasons in support of airborne transmission of SARS-CoV-2. Lancet, Vol. 390, No. 10285; pp. 1603-1605.

Greenhalgh, T., Schmid, M. B., Czypionka, T., Bassler, D. and Gruer, L. (2020). Face masks for the public during the Covid-19 crisis. British Medical Journal, Vol. 369.

Greenstone, M. and Nigam, V. (2020). Does social distancing matter? University of Chicago, Becker Friedman Institute for Economics Working Paper No. 2020-26.

Greer, S. L., King, E. J., Massard da Fonseca, E. and Peralta-Santos, A. (2021). Coronavirus politics: the comparative politics and policy of Covid-19. University of Michigan Press.

Grundy, E. M. and Murphy, M. (2017). Population ageing in Europe. In: Oxford Textbook of Geriatric Medicine. Third edition. (ed.) Michel, J. P., Beattie, B. L., Martin, F. C. and Walston, J. D. (2017).

Guerrieri, V., Lorenzoni, G., Straub, L. and Werning, I. (2020). Macroeconomic implications of Covid-19: can negative supply shocks cause demand shortages? NBER Working Paper No. 26918.

Hafeez, S., Din, M., Zia, F., Ali, M. and Shinwari, Z. K. (2021). Emerging concerns regarding Covid-19; second wave and new variant. Journal of Medical Virology, Vol. 93, No. 7; pp. 4108-4110.

Hale, T., Angrist, N., Goldszmidt, R., Kira, B., Petherick, A., Phillips, T., Webster, S., Cameron-Blake, E., Hallas, L., Majumdar, S. and Tatlow, H. (2021). A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker). Nature Human Behaviour, Vol. 5; pp. 529-538.

Hall, D. (2010). Why we need public spending. PSIRU, Business School, University of Greenwich. Available at: https://www.world-psi.org/sites/default/files/documents/research/en_why_we_need_public_spending_no_signature.pdf

Hammitt, J. K. (2020). Valuing mortality risk in the time of Covid-19. Journal of Risk and Uncertainty, Vol. 61; pp. 129-154.

Hayakawa, K. and Mukunoki, H. (2021). Impacts of lockdown policies on international trade. Asian Economic Papers, Vol. 20, No. 2; pp. 123-141.

He, X., Hong, W., Pan, X., Lu, G. and Wei, X. SARS CoV-2 Omicron variant: characteristics and prevention. MedComm, Vol. 2; pp. 838-845.

Hellewell, J. et al. (2020). Feasibility of controlling Covid-19 outbreaks by isolation of cases and contacts. The Lancet Global Health, Vol. 8, No. 4; pp. e488-e496.

Hensvik, L. and Skans, O. N. (2020). Covid-19 crisis response monitoring: Sweden. IZA Institute of Labor Economics: Initiated by Deutsche Post Foundation. Available at: https://covid-19.iza.org/wp-content/uploads/2020/05/IZA_CrisisMonitoring_SE.pdf

Hepburn, C., O'Callaghan, B., Stern, N., Stiglitz, J. and Zenghelis, D. (2020). Will Covid-19 fiscal recovery packages accelerate or retard progress on climate change? Oxford Review of Economic Policy, Vol. 36, No. 1; pp. S359-S381.

Holland, P. W. (1986). Statistics and causal inference. Journal of the American Statistical Association, Vol. 81, No. 386; pp. 945-960.

IEA (2020a). Global Energy Review 2020 The impacts of the Covid-19 crisis on global energy demand and CO2 emissions. Available at: https://www.iea.org/reports/global-energy-review-2020/context-a-world-in-lockdown

IEA (2020b). Reductions of electricity demand after implementing lockdown measures in selected countries, weather corrected, 0 to 118 days. Available at: https://www.iea.org/data-and-statistics/charts/reductions-of-electricity-demand-after-implementing-lockdown-measures-in-selected-regions-weather-corrected

IMF (International Monetary Fund) (2020). The great lockdown: dissecting the economic effects. World Economic Outlook, chapter 2; pp. 65-84.

Jebril, N. M. T. (2020). World Health Organization declared a pandemic public health menace: a systematic review of the Coronavirus disease 2019 "Covid-19". International Journal of Psychosocial Rehabilitation, Vol. 24, No. 9; pp. 2784-2795.

Kaplan, S., Lefler, J. and Zilberman, D. (2020). The political economy of Covid-19. Applied Economic Perspectives and Policy, Vol. 44, No. 1; pp. 477-488.

Karim, S. S. A. and Karim, Q. A. (2021). Omicron SARS-CoV-2 variant: a new chapter in the Covid-19 pandemic. The Lancet, Vol. 398, No. 10317; pp. 2126-2128.

Kharroubi, S. and Saleh, F. (2020). Are lockdown measures effective against Covid-19? Frontiers in Public Health, Vol. 8; pp. 1-4.

Kok, J. L. C. (2020). Short-term trade-off between stringency and economic growth. Covid Economics, Vol. 60; pp. 172-189.

Kong, E. and Prinz, D. (2020). Disentangling policy effects using proxy data: which shutdown policies affected unemployment during the Covid-19 pandemic? Journal of Public Economics, Vol. 189; pp. 1-39.

Kraemer, M. U. G. et al. (2020). The effect of human mobility and control measures on the Covid-19 epidemic in China. Science, Vol. 368; pp. 493-497.

Kumar, A. and Rajasekharan Nayar, K. (2021). Covid-19 and its mental health consequences. Journal of Mental Health, Vol. 30, No. 1; pp. 1-2.

Leshem, E. and Wilder-Smith, A. (2021). Covid-19 vaccine impact in Israel and a way out of the pandemic. The Lancet, Vol. 397, No. 10287; pp. 1783-1785.

Liu, D., Clemente, L., Poirier, C., Ding, X., Chinazzi, M., Davis, J., Vespignani, A. and Santillana, M. (2020). Real-time forecasting of the Covid-19 outbreak in Chinese provinces: machine learning approach using novel digital data and estimates from mechanistic models. Journal of Medical Internet Research, Vol. 22, No. 8.

Liu, X., Ornelas, E and Shi, H. (2021). The trade impact of the Covid-19 pandemic. Centre for Economic Performance. Discussion Paper No. 1771.

Liu, Y., Sandmann, F. G. et al. (2021a). Optimizing health and economic impacts of Covid-19 vaccine prioritization strategies in the WHO European Region. medRxiv, https://doi.org/10.1101/2021.07.09.21260272

Lopez-Valcarcel, B. G. and Vallejo-Torres, L. (2020). The costs of Covid-19 and the cost-effectiveness of testing. Applied Economic Analysis, Vol. 29, No. 85; pp. 77-89.

Lu, H., Stratton, C.W., Tang Y.-W. (2020). Outbreak of pneumonia of unknown etiology in Wuhan, China: The mystery and the miracle J. Med. Virol., 92 (4), pp. 401-402.

Mahieu, G., Pfeiffer, P., Varga, J. and in 't Veld, J. (2021). A stylized quantitative assessment of Next Generation EU investment. CEPR Research-based policy analysis and commentary from leading economists. Available at: https://voxeu.org/article/stylized-quantitative-assessment-next-generation-eu-investment

Martonosi, S. E., Behzad, B. and Cummings, K. (2021). Pricing the Covid-19 vaccine: a mathematical approach. Omega, Vol. 103; pp. 1-7.

Marziano, V., Guzzetta, G., Mammone, A., Riccardo, F. et al. (2021). The effect of Covid-19 vaccination in Italy and perspectives for living with the virus. Nature Communications, Vol. 12, No. 7272.

Martin, G. P., Hanna, E., McCarteney, M. and Dingwall, R. (2020). Science, society, and policy in the face of uncertainty: reflections on the debate around face coverings for the public during Covid-19. Critical Public Health, Vol. 30, No. 5; pp. 501-508.

Masterman, C. J. and Viscusi, W. K. (2018). The income elasticity of global values of a statistical life: stated preference evidence. Journal of Benefit-Cost Analysis, Vol. 9, No. 3; pp. 407-434.

McKay, B., Calfas, J. and Ansari, T. (2020). Coronavirus declared pandemic by World Health Organization. Wall Street Journal archived from original on 11th March 2020.

Menut, L., Bessagnet, B., Siour, G., Mailler, S., Pennel, R. and Cholakian, A. (2020). Science of the Total Environment, Vol. 741; pp. 1-9.

Meslé, M. M., Brown, J., Mook, P., Hagan, J. et al. (2021). Estimated number of deaths directly averted in people 60 years and older as a result of Covid-19 vaccination in the WHO European Region, December 2020 to November 2021. Eurosurveillance, Vol. 26, No. 47.

Michello, F. A. and Ford, W. F. (2006). The unemployment effects of proposed changes in social security's "normal retirement age". Business Economics, pp. 38-46.

Migone, A. R. (2020). The influence of national policy characteristics on Covid-19 containment policies: a comparative analysis. Policy Design and Practice, Vol. 3, No. 3; pp. 259-276.

Milas, C. (2021). Covid-19 restrictions and UK GDP growth. Milas, Costas, COVID-19 Restrictions and UK GDP Growth (June 15, 2021). University of Liverpool. Available at SSRN: https://ssrn.com/abstract=3867485

Miles, D., Stedman, M. and Heald, A. (2020). Living with COVID-19: balancing costs against benefits in the face of the virus. National Institute Economic Review, No. 253; pp. 60-76.

Miles, D., Stedman, M. and Heald, A. (2021). "Stay at home, protect the national health service, save lives": a cost benefit analysis of the lockdown in the United Kingdom. The International Journal of Clinical Practice, Vol. 75, No. 3.

Ministry of Finance Denmark (2021). Economic Survey, December 2021. Available at: https://en.fm.dk/publications/2021/december/economic-survey-december-2021/

Mitha, S. (2020). UK Covid-19 diary: policy and impacts. National Tax Journal, Vol. 73, No. 3; pp. 847-878.

Mofijur, M., Rizwanul Fattah, I. M., Asraful Alam, Md. et al. (2021). Impact of Covid-19 on the social, economic, environmental and energy domains: lessons learnt from a global pandemic. Sustainable Production and Consumption, Vol. 26; pp. 343-359.

Mohan, J. R. (2009). International Business. Oxford University Press. New Delhi and New York ISBN 0-19-568909-7.

Mousazadeh, M., Paital, B., Naghdali et al. (2021). Positive environmental effects of the Coronavirus 2020 episode: a review. Environment, Development and Sustainability, Vol. 23; pp. 12738-12760.

Mukaka M. M. (2012). Statistics corner: A guide to appropriate use of correlation coefficient in medical research. Malawi medical journal: the journal of Medical Association of Malawi, 24(3), 69–71.

Narlikar, A. and Sottilotta, C. E. (2021). Pandemic narratives and policy responses: west European governments and Covid-19. Journal of European Public Policy, Vol. 28, No. 8; pp. 1238-1257.

National Audit Office (NAO) UK government (2021). Covid-19 cost tracker. Available at: https://www.nao.org.uk/covid-19/cost-tracker/#

Nicola, M., Alsafi, Z., Sohrabi, C., Kerwan, A. Al-Jabir, A., Iosifidis, C., Agha, M. and Agha, R. (2020). The socio-economic implications of the Coronavirus pandemic (Covid-19): a review. International Journal of Surgery (London, England), Vol. 78; pp. 185-193.

Nogrady, B. (2020). What the data say about asymptomatic Covid-19 infections. Nature, Vol. 587; pp. 534-535.

Odone, A., Delmonte, D., Gaetti, G. and Signorelli, C. (2021). Doubled mortality rate during the Covid-19 pandemic in Italy: quantifying what is not captured by surveillance. Public Health, Vol. 190; pp. 108-115.

OECD (2022). General government spending by destination (indicator). Available at: https://data.oecd.org/gga/general-government-spending-by-destination.htm

OECD (2021a). OECD Economic Outlook, Interim Report September 2021. Keeping the recovery on track, OECD Publishing.

OECD (2021b). The long-term implications of the Covid-19 pandemic and recovery measures on environmental pressures: a quantitative exploration. OECD Environment Working Paper No. 176.

OECD (2021c). General government spending by destination (indicator). Available at: https://data.oecd.org/gga/general-government-spending-by-destination.htm#indicator-chart (Accessed on 26 November 2021).

OECD (2021d). OECD Economic Survey Denmark, December 2021. OECD Publishing, Paris. Available at: https://www.oecd.org/economy/surveys/denmark-2021-OECD-economic-survey-overview.pdf

OECD (2021e). OECD Economic Survey Italy, September 2021. OECD Publishing, Paris. Available at: https://www.oecd-ilibrary.org/economics/oecd-economic-surveys-italy-2021_07d8b9cd-en;jsessionid=_yDmaEv8JXvilfFc2ZvBEpJ5.ip-10-240-5-16

OECD (2020a). Testing for Covid-19: a way to lift confinement restrictions. Tackling Coronavirus (Covid-19): contributing to a global effort. Available at: https://www.oecd.org/coronavirus/policy-responses/testing-for-covid-19-a-way-to-lift-confinement-restrictions-89756248/

OECD (2020b). Women at the core of the fight against Covid-19 crisis. Tackling Coronavirus (Covid-19) contributing to a global effort. Available at: https://www.oecd.org/coronavirus/policy-responses/women-at-the-core-of-the-fight-against-covid-19-crisis-553a8269/

OECD (2020c). Cities policy responses. Tackling Coronavirus (Covid-19) contributing to a global effort. Updated 23rd July 2020. Available at: https://www.oecd.org/coronavirus/policy-responses/cities-policy-responses-fd1053ff/

OECD (2020d). Evaluating the initial impact of Covid-19 containment measures on economic activity. Tackling Coronavirus (Covid-19) contributing to a global effort. Updated 23rd July 2020. Available at: https://www.oecd.org/coronavirus/policy-responses/evaluating-the-initial-impact-of-covid-19-containment-measures-on-economic-activity-b1f6b68b/

OECD (2018). Cost-benefit analysis and the environment: further developments and policy use. OECD Publishing, Paris.

OECD (2008). OECD key environmental indicators 2008. OECD Environment Directorate, Paris, France.

Office for National Statistics UK (2021). Deaths involving Covid-19 by vaccination status, England: deaths occurring between 2 January and 2 July 2021. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/deathsinvolvingcovid19byvaccinationstatusengland/deathsoccurringbetween2januaryand2july2021

Ozkan, A., Ozkan, G., Yalaman, A. and Yildiz, Y. (2021). Climate risk, culture and the Covid-19 mortality: a cross-country analysis. World Development, Vol. 141; pp. 1-11.

Painter, M. O. and Qiu, T. (2020). Political beliefs affect compliance with Covid-19 social distancing orders. Covid Economics, Vol. 4, No. 14; pp. 103-123.

Panovska-Griffiths, J., Kerr, C. C. et al. (2020). Determining the optimal strategy for reopening schools, the impact of test and trace interventions, and the risk of occurrence of a second Covid-19 epidemic wave in the UK: a modelling study. The Lancet Child and Adolescent Health, Vol. 4, No. 11; pp. 817-827.

Pei, J., de Vries, G. and Zhang, M. (2021). International trade and Covid-19: city-level evidence from China's lockdown policy. Journal of Regional Science; pp. 1-26.

Peterson-KFF Health System Tracker (2021). Covid-19 preventable mortality. Available at: https://www.healthsystemtracker.org/brief/covid19-and-other-leading-causes-of-death-in-the-us/

Phelps, C. E. and Mushlin, A. I. (1991). On the (near) equivalence between cost-effectiveness and cost-benefit analysis. International Journal of Technology Assessment in Health Care, Vol. 7; pp. 12-21.

Pianta, M. (2021). The impact of the pandemic on industries. A conceptual map and key processes. Background paper for the UNIDO Industrial Development Report 2022.

Pianta, M., Lucchese, M. and Nascia, L. (2021). The Italian government's economic-policy response to the Coronavirus crisis. Contemporary Italian Politics, Vol. 13, No. 2; pp. 210-225.

Pieroni, V., Facchini, A., Riccaboni, M. (2021). Covid-19 vaccination and unemployment risk: lessons from the Italian crisis. Scientific Reports, 11, 18538.

Pouwel, K. B., Pritchard, E., Matthews, P. C., Stoesser, N. et al. (2021). Effect of Delta variant on viral burden and vaccine effectiveness against new SARS-CoV-2 infections in the UK. Nature Medicine, Vol. 27; pp. 2127-2135.

Rahman, A. et al. (2020). Data-driven dynamic clustering framework for mitigating the adverse economic impact of Covid-19 lockdown practices. Sustainable Cities and Society, Vol. 62.

Richardson, J., Gustaffson, G. and Grant, J. (1982). The concept of policy style. In Policy Styles in Western Europe, edited by J. Richardson, 1-14. Crows Nest: George Allen & Unwin.

Robinson, R. (1993). Cost-effectiveness analysis. British Medical Journal, Vol. 307; pp. 793-795.

Robinson, J. F., Rios de Anda, I. et al. (2020). How effective are face coverings in reducing transmission of Covid-19? Available at: https://www.medrxiv.org/content/10.1101/2020.12.01.20241992v1.full-text

Rocklöv, J. and Sjödin, H. (2020). High population densities catalyse the spread of Covid-19. Journal of Travel Medicine, Vol. 27, No. 3.

Rogani, A. (2021). The influence of Covid-19 vaccination on daily cases, hospitalisation, and death rate in Tennessee, United States: case study. JMIRx, Vol. 2, No. 3.

Rossman, H., Shilo, S., Meir, T., Gorfine, M., Shalit, U. and Segal, E. (2021). Covid-19 dynamics after a national immunization program in Israel. Nature Medicine, Vol. 27; pp. 1055-1061.

Sacco, C., Mateo-Urdiales, M., Petrone, D., Spuri, M. et al. (2021). Estimating Covid-19 averted cases, hospitalization, intensive care unit admissions and deaths by Covid-19 vaccination, Italy, January – September 2021. Eurosurveillance, Vol. 26, No. 47.

Saglietto, A., D'Ascenzo, F., Biondi Zoccai, G and De Ferrari, G. M. (2020). Covid-19 in Europe: the Italian lesson. The Lancet, Vol. 395, No. 10230; pp. 1110-1111.

Schneider, R., Masselot, P., Vicedo-Cabrera, A. M., Sera, F. et al. (2022). Differential impact of government lockdown policies on reducing air pollution levels and related mortality in Europe. Nature, Vol. 12, No. 726.

Shitrit, P., Zuckerman, N. S., Mor, O., Gottesman, B.-S. and Chowers, M. (2021). Nosocomial outbreak caused by the SARS-CoV-2 Delta variant in a highly vaccinated population, Israel, July 2021. Euro Surveillance, Vol. 26, No. 39.

Shlomai, A., Leshno, A., Sklan, E. H. and Leshno, M. (2021). Modeling social distancing strategies to prevent SARS-Cov-2 spread in Israel: a cost-effectiveness analysis. Value in Health, Vol. 24, No. 5; pp. 607-614.

Signorelli, C., Sconamiglio, T. and Odone, A. (2020). Covid-19 in Italy: impact of containment measures and prevalence estimates of infection in the general population. Acta Biomed, Vol. 91, No. 3; pp. 175-179.

Silva, M. L., Perrier, L., Cohen, J. M., Paget, W. J., Mosnier, A. and Spath, H. M. (2015). A literature review to identify factors that determine policies for influenza vaccination. Health Policy (Amsterdam, Netherlands), Vol. 119, No. 6; pp. 697-708.

Smith, M. J., Bensimon, C. M., Perez, D. F., Sahni S. S. and Upshur, R. E. G. (2012). Restrictive measures in an influenza pandemic: a qualitative study of public perspectives. Canadian Journal of Public Health, Vol. 103, No. 5; pp. e348-e352.

Socrates, M., K. and Lashitew, A. A. (2021). The effect of lockdown policies on international trade: evidence from Kenya. Global working paper no. 148. Global Economy and Development at Brookings.

Stock, J. H. and Watson, M. W. (2015). Introduction to econometrics. 3rd updated version. Pearson Education.

Su, C-W, Dai, K., Ullah, S. and Andlib, Z. (2021). Covid-19 pandemic and unemployment dynamics in European economies. Economic Research, Vol. 34; pp. 1-13.

Subbaraman, N. (2020). Why daily death tolls have become unusually important in understanding the coronavirus pandemic. Nature. DOI: 10.1038/d41586-020-01008-1.

Sunjaya, A. P. and Jenkins, C. (2020). Rationale for universal face masks in public against Covid-19. Respirology.

Torry, E. (2021). Effectiveness of Coronavirus disease 19 lockdowns: a cross-regional comparison. Drake Undergraduate Social Science Journal, Spring 2021 edition.

Tregoning, J. S., Flight, K. E., Higham, S. L., Wang, Z. and Pierce, B. F. (2021). Progress of the Covid-19 vaccine effort: viruses, vaccines and variants versus efficacy, effectiveness and escape. Nature Reviews Immunology, Vol. 21, No. 10; pp. 626-636.

Tyshenko, M. G. and Paterson, C. (2010). SARS unmasked: risk communication of pandemics and influenza in Canada. MontrealandKingston: McGill-Queen's University Press.

Ufficio Parlamentare di Bilancio (2020). Rapporto sulla politica di bilancio 2021. Roma, Dicembre 2020. Available at: https://www.upbilancio.it/wp-content/uploads/2020/12/Rapporto_pol_2021-per-sito.pdf

UK Government (2021). "Unimaginable" cost of Test & Trace failed to deliver central promise of averting another lockdown. Available at: https://committees.parliament.uk/committee/127/public-accounts-committee/news/150988/unimaginable-cost-of-test-trace-failed-to-deliver-central-promise-of-averting-another-lockdown/

UN (United Nations) (2020). Covid-19 in an urban world. Policy Brief, United Nations. Available at: https://www.un.org/sites/un2.un.org/files/sg_policy_brief_covid_urban_world_july_2020.pdf

US Environmental Protection Agency (EPA) (2014). Guidelines for preparing for economic analyses. National Centre for Environmental Economics, Office of Policy. Available at: https://www.epa.gov/sites/default/files/2017-08/documents/ee-0568-50.pdf

Vanaparthy, R., Mohan, G., Vasireddy, D. and Atluri, P. (2021). Review of Covid-19 viral vector-based vaccines and Covid-19 variants. Le Infezioni in Medicina, Vol. 29, No. 3; pp. 328-338.

Vandepitte, S., Alleman, T., Nopens, I, Baetens, J., Coenen, S. and De Smedt, D. (2021). Cost-effectiveness of Coronavirus Disease 2019 policy measures: a systematic review. Value in Health. Article under Press.

Vecino-Ortiz, A. I., Congote, J. V., Bedoia, S. Z. and Cucunuba, Z. M. (2021). Impact of contact tracing on Covid-19 mortality: an impact evaluation using surveillance data from Columbia. Plos One, Vol. 16, No. 3.

Vincent, J. and Taccone, F. S. (2020). Understanding pathways to death in patients with Covid-19. Comment, The Lancet Respiratory Medicine, Vol. 8, No. 5; pp. 430-432.

Viscusi, W. K. (2020). Pricing the global health risks of the Covid-19 pandemic. Journal of Risk and Uncertainty, Vol. 61; pp. 101-128.

Wang, C. S. and Otani, Y. Removal of nanoparticles from gas streams by fibrous filters: a review. Industrial and Engineering Chemistry Research, Vol. 52, No. 1; pp. 5-17.

Wang, Q., Wang., S. and Jiang, X. (2021). Preventing a rebound in carbon intensity post-Covid-19 – lessons learned from the change in carbon intensity before and after the 2008 financial crisis. Sustainable Production and Consumption, Vol. 27; pp. 1841-1856.

WHO (World Health Organization) (2021a). Covid-19 Weekly Epidemiological Update. Edition 62, published 19th October 2021. Available at: https://www.who.int/publications/m/item/weekly-epidemiological-update-on-covid-19---19-october-2021

WHO (World Health Organization) (2021b). Considerations for implementing and adjusting public health and social measures in the context of Covid-19. Available at: https://www.who.int/publications/i/item/considerations-in-adjusting-public-health-and-social-measures-in-the-context-of-covid-19-interim-guidance

WHO (2021c). World Health Organization SAGE roadmap for prioritizing uses of Covid-19 vaccines in the context of limited supply. Available at: https://www.who.int/publications/i/item/who-sage-roadmap-for-prioritizing-uses-of-covid-19-vaccines-in-the-context-of-limited-supply

WHO (2021d). Contact tracing in the context of Covid-19. Interim guidance, 1st February 2021. Available at: https://apps.who.int/iris/bitstream/handle/10665/339128/WHO-2019-nCoV-Contact_Tracing-2021.1-eng.pdf?sequence=24&isAllowed=y

WHO (2020a). Covid-19 public health emergency of International Concern (PHEIC) Global Research and innovation forum: towards a research roadmap. World Health Organization Geneva. Available at: https://www.who.int/publications/m/item/covid-19-public-health-emergency-of-international-concern-(pheic)-global-research-and-innovation-forum

WHO (2020b). Coronavirus disease 2019 (Covid-19). Situation Report 43. World Health Organization, Geneva. Available at: https://apps.who.int/iris/handle/10665/331354

WHO (2020c). Coronavirus disease 2019 (Covid-19). Situation Report 50. World Health Organization, Geneva. Available at: https://apps.who.int/iris/handle/10665/331450

WHO (2020d). International guidelines for certification and classification (coding) of Covid-19 as cause of death. Based on International Statistical Classification of Diseases, 16th April 2020. Available at: https://www.who.int/classifications/icd/Guidelines_Cause_of_Death_COVID-19.pdf

Witteveen, D. (2020). Sociodemographic inequality in exposure to Covid-19 induced economic hardship in the United Kingdom. Research in Social Stratification and Mobility, Vol. 69.

Wong, D. W. S. and Li, Y. (2020). Spreading of Covid-19: density matters. Plos One, Vol. 15, No. 12.

World Bank (2021). Global Economic Prospects. International Bank for Reconstruction and Development. Available at: https://www.worldbank.org/en/publication/global-economic-prospects

Wu, X., Nethery, R. C., Sabath, M. B., Braun, D. and Dominici, F. (2020). Air pollution and Covid-19 mortality in the United States: strengths and limitations of an ecological regression analysis. Science Advances, Vol. 6, No. 45.

Yeyati, E. L. and Filippini, F. (2021). Social and economic impact of Covid-19. Brookings Global Working Paper No. 158. Global Economy and Development at Brookings.

GREEN
Centre for Geography, Resources, Environment, Energy and Networks
via Röntgen, 1
20136 Milano - Italia

www.green.unibocconi.eu