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ABSTRACT

Designing Reopening Strategies in the Aftermath of COVID-19 Lockdowns: Some Principles with an Application to Denmark*

Governments across the globe have responded to the threat of the Covid-19 virus by imposing substantial lockdown measures largely guided by epidemiological concerns. These lockdowns come at significant economic costs with increased risk of e.g. mass unemployment. Recently, debates have emerged on how to design reopening strategies that achieve the largest possible economic gains while constraining the spread of the virus. The present paper identifies five central challenges economists face in delineating the trade-off between containing the virus from spreading and the economic consequences and costs of lockdown measures. While the principle of tradeoffs is at the core of economics, the road to actually operationalizing this perspective on Covid-19-related lockdown measures is still unpaved. We present several workarounds to the identified challenges based on a recently prepared economic expert assessment commissioned by the Danish government. A reduced form indicator for virus spread pressure is developed and mapped against economic indicators. The resulting tool captures the trade-off between health and economic concerns and can guide the design of reopening strategies.

JEL Classification: A1, H3

Keywords: COVID-19, reopening strategies, fiscal response

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* This article is based on insights we have derived when preparing an expert assessment report for the Danish Government. Our thinking on the topic has benefited from numerous discussions with colleagues and ample assistance from staff economists at the Ministry of Finance and Ministry of Economics, Denmark.

1. Introduction

The Covid-19 pandemic has forced policy makers across the world to impose severe lockdowns on activity in their respective jurisdictions, see for example Hale et al. (2020). While the initial lockdown protocols followed predominantly health considerations including pandemic forecast models and the need to maintain essential infrastructure, such as access to food supplies, the reopening debate in several countries has evolved to include a focus on implications for businesses and the overall economic costs and benefits of continuing or lifting lockdown measures.

The economic principle guiding a reopening strategy is simple: maximize the economic return for a given level (or increase) in the infection rate (or other relevant health outcome). However, there is a huge leap in going from theory to an application, since it is extremely difficult to assess both the economic benefit from removing a certain restriction, and the associated health effect. Still, the trade-off between health and economic considerations has appeared in discussions of reopening strategies in a number of countries; examples include Finland and Norway (see e.g. Norwegian expert group, 2020).

While the existence of such tradeoffs falls naturally within the realm of economic modeling and thinking about Covid-19 (see for example Alvarez, 2020, Anand (2020) or Forslid and Herzing, 2020), the actual implementation when it comes to advising policy makers turns out to face some novel problems. In other words, economists are forced to build their ship while sailing.

The current paper identifies some of the central challenges in operationalizing the tradeoff between health and economic considerations and presents a series of workarounds (and their shortcomings) to these challenges. These principles are applied to Denmark based on our recent experience of having to prepare a background report for the Danish government requested in the process of designing a reopening strategy (Andersen, Schröder and Svarer, 2020).[1] The background is that the lockdown measures taken to contain the spread of the virus had proved successful, creating some room for a gradual reopening of the economy.

Based on the Danish case, we identify five central challenges that we expect will be present, and have to be resolved, in any attempt of a meaningful assessment of the tradeoffs between health and economic considerations in a reopening/lockdown debate. Firstly, an epidemiological input is required both on the status of containing the virus and on the consequences for pandemic developments that stem from lifting certain lockdown restrictions. The latter is a particular challenge due to the complexity and interactions between lockdown measures across sectors, but also because infection data is in early stages sparse and arrives with significant delay (depending on testing strategies). Furthermore, pandemic forecast models are continuously updated in light of new insights and data. These inputs must be translated into measures of how various economic activities affect the risk of spreading the virus. Second, actual lockdown

[1] To guide the reopening decisions, the Danish Parliament appointed an expert group consisting of the three authors of this article and required an economic assessment of various reopening strategies. See Section 2 for further information.

measures have to be mapped on economic activities and sectors. While this is straightforward for many items (such as closing down restaurants or certain shops), the impact of for example travel bans will strike in many sectors and operate through several channels. Thirdly, only a fraction of the actual decline in economic activities for a given sector is caused by actual lockdown measures. There is a difficult identification problem, because changed consumer behavior and rest-of-world effects may play a far larger role for the decline in activity observed in most sectors than the actual health and lockdown restrictions imposed. Fourth, standard measures of economic activity are an ill fit for the economic consequences of lockdown measures in several sectors. For example, the enforced shutdown of public sector activities (such as publicly funded educational institutions) will by the accounting principles of GDP, where these activities are included by their value of input costs, not show up as a decline in production value as long as public wages continue to be paid. Thus, some consequences, e.g. running via education, will not show in the short run. Fifth, remedies such as the ability to produce output through remote work (see Dingel and Neiman, 2020) in response to lockdown restrictions will affect the true economic value of lifting restrictions. Again, these measures do not lend themselves to easy quantitative assessment.

The paper is structured as follows. Section 2 presents a brief history of the Danish Covid-19 policy response to date, including the timing of lockdown and lifting of measures and the role of the expert report of Andersen, Schröder and Svarer (2020) in this process. Section 3 presents a novel reduced form approach to operationalizing epidemiological model insights into a composite measure of virus spread risk per sector, or rather per lifted lockdown on a given sector. Section 4 discusses the underlying considerations for mapping restrictions onto sectors and how to identify the economic effects of lockdown measures. Section 5 illustrates our economic outcome measures and presents the actual tradeoff assessment of our analysis. Section 6 concludes by reporting additional items of central relevance that are not included in the metrics of our tradeoff assessment, and records items for future research.

2. A brief history of lockdown measures in Denmark

Denmark is, among the European countries, an example of a relatively early and broad lockdown despite moderate infection numbers. The lockdown was announced March 11thand the aim of the policy was to contain the spread of the virus to avoid an overburdening of the healthcare system. Key indicators have thus been the number of confirmed new cases, the number of hospitalized patients and patients in intensive care. Because of the sharp lockdown, social distancing measures and altered behavior in the population at large, Covid-19 infection growth rates in Denmark started to decline, and it became clear that developments were well within the capacity of the healthcare system. This, in turn, fueled an early debate about easing lockdown measures. After a first ad hoc relaxation announced on April 6th, Covid-19 case numbers continued to be moderate. Table 1 gives examples of measures and a rough timeline of lockdown events and easing (past, present and planned future). There are no announced decisions on travel restrictions, and the reopening strategy will be accompanied by requirements regarding physical distance and hygiene that will be continuously updated. In

addition, there are increased testing efforts, and a randomized testing initiative will provide information on the contamination incidence and antibody status in the population.

Table 1: Selected lockdown and reopening measures in the Danish economy (status May 14th)					
	Lockdown	**Reopening**			
Phase		Phase 1	Phase 2	Phase 3	Phase 4
Announced	March 11th	April 6th	May 7th	May 8th	May 8th
Implemented	March 12th	April 20th	May 8th to May 18th	June 8th	August
Content	• [all measures displayed in Phase 1 -4] • Border and travel restrictions	• Daycare institutions • Primary school for grades 0 to 5 • Graduating cohorts in high schools • A number of sectors with one-to-one contact. E.g. hairdressers, beauty shops, and psychologists • Courts • Lowered restrictions on public transport and physical distance measures for private companies	• Shopping centers and department stores • Primary school for remaining grades • Primary boarding schools (a popular Danish option for 9th and 10th grades) • Restaurants and cafes • Professional sports (no spectators) • Amateur sports (outdoor) • Libraries and places of worship	• Assembly restriction changes from 10 to 30-50 people • Museums, galleries, cinemas, theatres • Amateur sports (indoor) • Amusement parks (outdoor) • Parts of the public sector that were locked-down	• All educational institutions including universities • Night clubs and music halls • Fitness centers • Amusement parks (indoor)
Total confirmed Covid19 cases and deaths. Stock data of hospitalized (pop: 5.8 mill.)	615 cases 0 deaths NN in hosp. NN in ICU	7515 cases 364 deaths 336 in hosp. 84 in ICU	10218 cases 522 deaths 205 in hosp. 42 in ICU		
Source: Danish Ministry of Finance, SSI, and authors' own summary of events.					

Policy guidance towards the reopening strategy of phase 2 and forward has been based on two expert assessments. First, a regular epidemiological report solicited by the Danish government from a group of independent experts hosted and coordinated by SSI (Statens Serum Institut under the Danish Ministry of Health). Second, the aforementioned assessment of the economic and health tradeoff by Andersen, Schröder and Svarer (2020), which had been requested by the government on May 1st 2020. The government received both reports on May 6th 2020.

Given, the early lockdown reaction in Denmark and hence also the early reopening debate, the Danish case provides some instructive insights for economists faced with the same assessment dilemma in other countries that are at other stages of the lockdown and reopening process. Moreover, the methods and tools presented in the next sections are also of potential value in decisions regarding a subsequent tightening of already eased or newly conceived lockdown measures should infection rates increase, or should a second Covid-19 wave strike.

3. A reduced form indicator of virus spread pressure

A crucial pre-condition for an assessment of tradeoffs between health and economic considerations is reliable indicators for the additional virus spread pressure stemming from an easing of different lockdown measures. Informing the economic assessments through fully-fledged epidemiological models (such as SIR or others), however, constitutes a considerable computational task. First of all, these models do not easily lend themselves to marginal assessment. Secondly, the available epidemiological models in Denmark are not structured by economic sector but by activity type. Thirdly, the underlying differential equation systems of epidemiological models are in the early stages of the Covid-19 crisis, with relatively few and volatile data on infections, unstable and model updates are thus frequent. This latter problem is further amplified in Denmark because testing strategies focused on people with Covid-19 symptoms only. Thus, this available data gives little insight on the general spread of the epidemic in Denmark, in particular since younger generations with less severe symptoms are underrepresented. Finally, social distancing measures, which may not necessarily constitute lockdown measures, appear to have empirically large effects on the virus spread scenarios, see Jarvis et al. (2020). Thus behavior in the population, such as the observation of physical distancing, may dominate in size and significance the effects from actual lockdown measures on virus spread.

The approach followed here is inspired by Benzell et al. (2020). It establishes an indicator of the infection pressure by comparing the risk of infection in various activities with the extent of contacts. Our starting point is the assessment of health effects provided by SSI (Statens Serum Institut under the Danish Ministry of Health) giving the direct infection risks for a number of activities (some of which can be linked to industries). This assessment was made on the basis of a 7-step scale from the lowest to the highest contamination risk of the specific activity, and it could thus be linked by us to different industries. For example, there is a low contamination pressure effect for libraries and museums, etc., while the contamination risk is at a medium level in, for example, restaurants and cafes, and high in e.g. nightclubs and music venues, cf. Figure 1 column 1.

Importantly, the externally provided 7-step scale is dealing only with infection risks associated with the activity itself, and thus does not take into account how widespread the activity is. However, the 7-step scale assessment includes important epidemiological features, such as the expected density of persons in a given premises, and the number of contacts between people from different contact networks, the extent of physical activity, etc. As can be seen from column 1 in Figure 1, this scale indicates that the contamination risk from visiting a nightclub is considerable; i.e. the risk of contamination for the individual guest is high. However, if only relatively few people go to nightclubs, the overall impact of the virus spread pressure on the country as a whole will be less severe than if it were an activity of greater prevalence. Accordingly, we arrive at our virus spread pressure index by including multiplicatively a measure of the number of people estimated to take part in a given activity (column 2 in Figure 1).

Finally, column 3 in Figure 1 shows the resulting virus spread pressure index. Obviously, there are several important caveats to the construction and interpretation of the index. Firstly, reliable statistics on the number of people participating in the various activities are not available in all areas that are subject directly or indirectly to lockdown measures (see the discussion in Section 4). Second, the simple approach weighting contamination risk information by the number of participants in the activity provides an imprecise assessment of the overall risk of infection.

Figure 1: Assessment of contamination risks across sectors

Source: Statens Serum Institut SSI (contamination riskindex), Statistics Denmark, and own calculations.

A more accurate combination of the two sources of information requires that significantly more time is spent on running actual health model simulations on the individual relaxing and tightening of lockdown measures and combinations of such measures. Yet, the urgency of political decision processes for both lockdown and reopening does not allow time for such more elaborate assessments. Nevertheless, as a means of quality control the resulting index was submitted for approval to SSI health officials to confirm that the index is a rough, but meaningful approximation for the overall infection effect.

While the index works for the assessment of tradeoffs in reopening the economy, it is not a tool well suited for predicting the expected infection development in the aftermath of a potential reopening. Among the many details that our index ignores is the lack of accounting for age composition and high-risk groups, which are known to significantly impact on the burden that the disease places on the health system. Furthermore, it should be noted that infection risk is calculated on an ordinal scale. Since we multiply such ordinal values with actual size data, it can give a false impression of quantitative precision. Despite this significant limitation, external assessment by the SSI considers that the approach chosen can be used to support the reopening decisions. The main uncertainty embedded in our approach is in terms of the actual virus spread pressure levels, and much less so in the ranking between different activities and sectors.

4. Mapping lockdown measures on sectors and assessing the role of restrictions versus other drivers of economic decline

Another principle challenge for delineating the trade-off between containing the virus from spreading and the economic consequences is the mapping of lockdown measures onto actual economic sectors. Lockdown measures range from maximum limits on the permitted number of participants at public gatherings, over travel restrictions to specific prohibition of activities (see Table 1). . While some restrictions, such as the closure of restaurants are easily mapped onto observable firms and sectors, others – such as a general recommendation for remote work - are not. Moreover, some effects are quantifiable, while others are not. This requires a careful consideration of the specific restrictions, and it is obviously associated with uncertainty.

Lockdown measures implemented to combat the spread of Covid-19 are only partially responsible for the economic downturn in the various sectors of the economy. Quite clearly, changes to behavior, fears of unemployment and other mechanisms associated with business cycle downturns will run as secondary effects on top of the actual direct effects stemming from lockdown measures.[2] In addition, for the small open economy case, foreign lockdown measures and economic sluggishness will transmit to the local economy through declining global economic activity. Those lockdown measures which can most directly affect particular sectors affect the service sector. However, in Denmark the home market oriented directly affected service sectors

[2] Note, however, that for the US, Lin and Meissner (2020) provide first evidence that by state variation in "stay-at-home" orders appear not to correspond to economic outcomes such as unemployment.

account for only 15% of total employment (10% of total value). This implies that the direct contribution of the lockdown restrictions to the overall economic decline has an upper limit.

Denmark and Sweden provide an interesting comparison that illustrates the difficulties in separating the direct lockdown effects from an overall – potentially behavioral driven – decline in activity. While Denmark implemented a relatively harsh and sudden lockdown policy (see Section 2), Sweden implemented only a few restrictions, such as remote teaching for high schools and universities, and else issued general guidelines for distance measures and public health precautions. Despite the stark difference in lockdown policies, both economies experience significant declines in economic activities. Based on credit card transaction data and transactions volume information from VAT records, Andersen, Schröder and Svarer (2020) find for the month of March that the activity level in the hotel and hospitality sectors declined in Denmark with 50%, and in Sweden by approximately 35%. For restaurants, figures are in the range of 40% and 20%, respectively.

Hence, an assessment of the likely benefits of easing certain lockdown measures in Denmark should not assume a return to pre-crisis activity levels, but at best to Swedish activity levels. By this principle, we are able to evaluate the likely direct effect of a lockdown measure, and hence the potential of easing individual measures for a number of sectors that are readily observed. We find for the case of Denmark, that the lockdown restrictions are assessed to reduce GDP by about 7%, and the first phase of the reopening constitutes about 4 percentage points of this (the large effect arises via the effect on effective labor supply from closure of day-care facilities), see Andersen, Schröder, Svarer (2020).

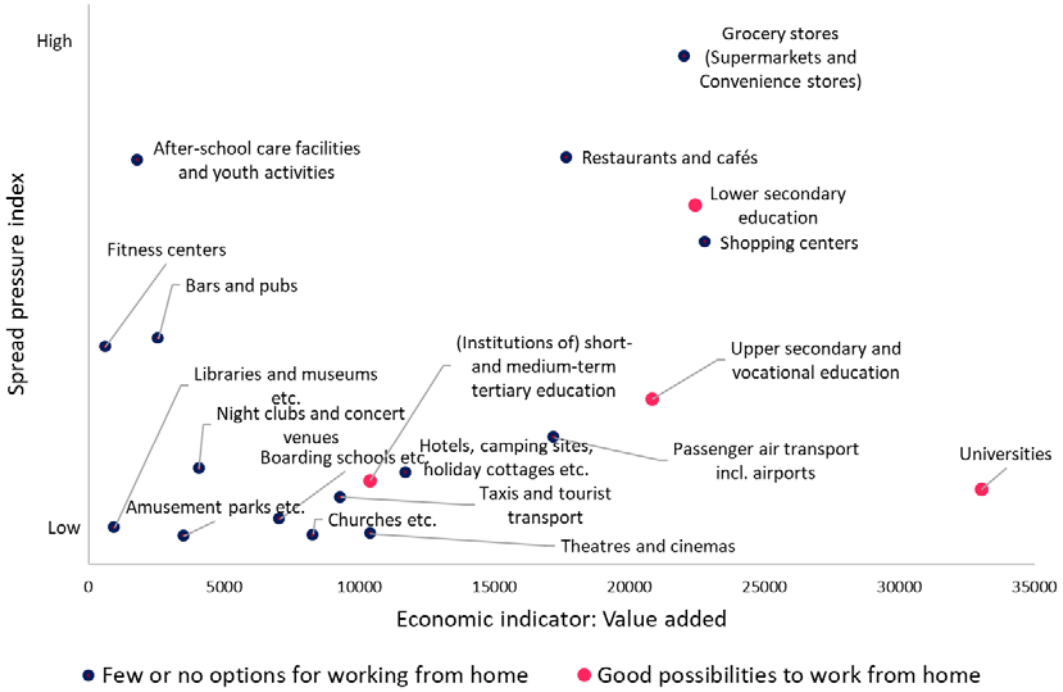
5. Feasible economic measures and mapping of health risk

In order to combine the /virus spread pressure (Section 3) with a measure of the economic impact of the various lockdown measures, we return now to the mapping of sectors to the individual lockdown restrictions (see Section 4) and express the different industries' significance via gross value added.[3] The calculations take into account that not all parts of the activity are affected by the lockdown measures in the industries. For example, corrections have been made to allow parts of the restaurant sector to continue selling food as take away. In the economic importance of the industry, value creation constitutes one part, but by means of input-output tables, the associated significance of the activity for subcontractors from other industries is included. For example, activity associated with the hospitality industry and shopping centers has indirect activity effects for other sectors (such as food production), compared to e.g. hotels and cinemas with more moderate sub-supplier effects; see Navaretti et al. (2020) for an in-depth discussion on the importance of using input output tables to informing reopening strategies. Importantly, in our calculations, the business structure and supply chains are implicitly assumed unchanged. In the short term, this is a reasonable assumption, as it takes time for companies to restructure their activities and production processes. For parts of the retail sector, however, it

[3] In the Danish report (Andersen, Svarer & Schröder, 2020), we also use employment as a measure of economic importance. The main findings of the analysis are robust to the choice of outcome measure.

is potentially relatively quick to convert to higher levels of online shopping, while in, for example, the hotel industry there is little opportunity to change the business model towards alternative sales channels.

Figure 2: Different industries' economic importance and health risks



Note: Gross value added is calculated incl. derived activity in other industries assessed on the basis of the national accounts' input-output table. Source: See Figure 1, and own calculations.

Figure 2 shows the results of this exercise. Compiling the indicator from Section 3 (virus spread pressure) with the economic significance introduced in Section 4 maps the importance of different sectors in terms of risk of spreading the virus and economic impact (the mapping would be fairly similar using employment as a metric of economic impact). Generally, activities of great economic importance also have a high virus spread pressure. For example, shopping centers have a relatively large economic significance. At the same time, shopping centers have a high impact according to the weighted indicator of virus spread pressure. In contrast, restaurants and cafés have less economic importance, and at the same time the indicator of spread pressure is slightly higher than for the shopping centers.

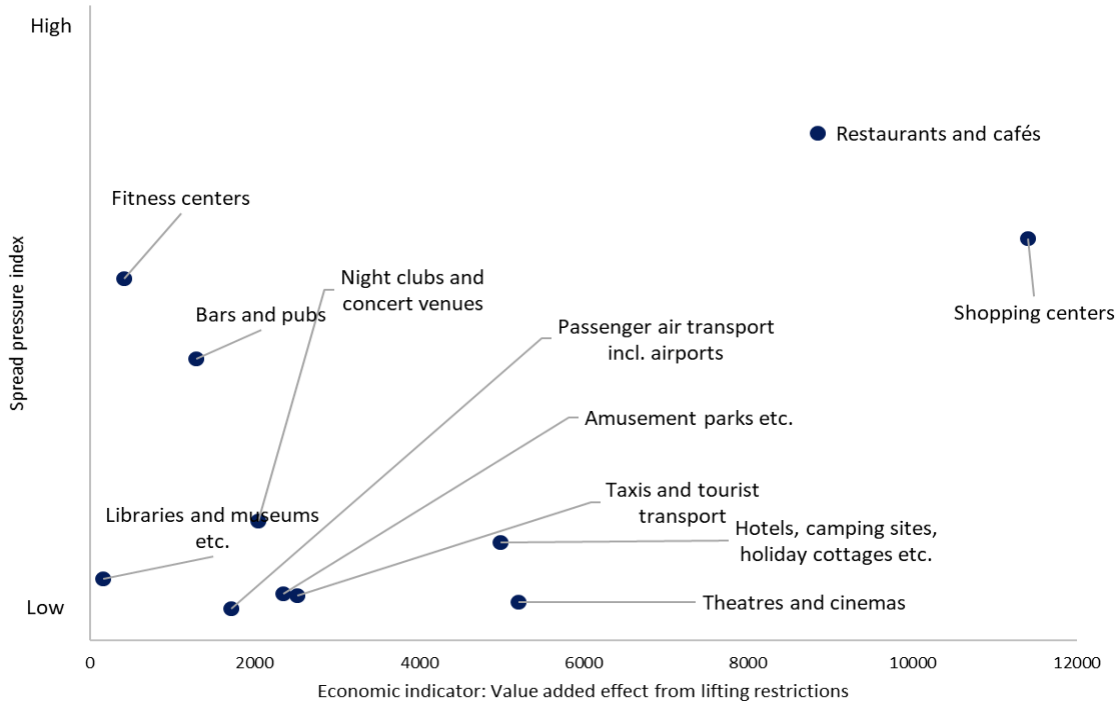
As a benchmark, we include – applying the same methodological steps laid out above - grocery shopping in Figure 2. At no time has this activity been closed during the Danish lockdown (due to its essential importance going beyond the value added metric). This illustrates a sense of economic significance of the various effects to be expected from a further easing of restrictions.

The rough comparison of the economic significance and the effect of infection in Figure 2 does not capture that some companies and institutions - with high gross value added - can maintain

production relatively easily in the short run using remote work (see e.g. Dingel & Neiman, 2020). In these situations, value creation can (to a great extent) be maintained, while at the same time dampening the virus spread pressure. This probably applies to much of the activity at universities, where certain types of research can be done from home and distance learning is an option. Similar conditions apply to many other sectors. To include this type of information at least qualitatively in the policy decision-making process, we augmented Figure 2 with a color code indicating a sector's ability to be (temporarily) conducted remotely. This is to show that these activities need not be prioritized in connection with the reopening.

The mapping in Figure 2 cannot directly be used to determine reopening strategy, since it denotes economic effect for a return to pre-crises normality However, as shown in Section 4, changes in behavior are likely to take place under Covid19 and lockdown measures per se cause only part of the total decline in activity. Hence, to guide reopening strategies it is necessary to consider the economic impact of the restriction, and thus the potential gain in economic activity by lifting the restriction, given that we do not return to pre-crises normality. This is done in the last step of our analysis and shown in Figure 3. We focus hereon the home market oriented service industries directly affected by lockdown measures. For these industries, we are able to quantify the direct effects of the lockdown measures based on well-defined economic goals (e.g. gross value added or employment). In this way, a quantification of the link between Covid19 risk and the socio-economic effect of the measures is obtained.

Figure 3: Spread pressure index and effect of lifting lockdown restrictions – private service sector



Note: The virus spread pressure indicator is an approximation based on information about the infection risk of a specific activity and the adjusted estimated extent of the activity. The economic significance is the estimated importance of removing measures aimed at curbing and mitigating the infection (but where demand is still affected by, for example, changed behavior. See the text for further elaboration.

Figure 3 gives the opportunity set available to policy makers when considering how to use the available maneuver room for reopening, and takes into account the effects on the spread pressure index and the economic effect from lifting restrictions. In this space, indifference curves between spread pressure (a bad) and economic value (a good) are positively sloped, and the further they are positioned to the south-east, the larger the utility. Depending on political preferences, the chart gives guidance on the choice of lockdown restrictions and sequences of reopening measures. Consider a policy maker having to choose between the reopening of all restaurants and cafes or the reopening of all shopping centers and department stores. By the logic of our assessment method presented in Figure 3, the reopening of all shopping centers dominates the reopening of all restaurants, since the former ranks higher in terms of economic value and lower in terms of virus spread pressure.

Figure 3 replicates to a large extent the qualitative results from Figure 2 but shows the scope for political priorities between health risk and economic effects for the private service industries only. There are no examples of industries in which a devolution of measures will have a large economic impact and a modest risk of infection. Shopping centers as well as restaurants and cafes are examples of large industries where the activities are linked to physical attendance, and

thus there is a relatively large economic significance, but there are also indications of a relatively large effect on the virus spread pressure. Political prioritization is therefore necessary.

6. Conclusion

The paper identifies some of the central challenges economists face in delineating the trade-off between containing the Covid19 virus with lockdown measures and the associated economic consequences and costs of such measures. We derive underlying principles and workarounds to the identified challenges based on a recently prepared economic expert assessment commissioned by the Danish government. Even though the focus of the present paper is on the involved principles, we note in passing that the priorities of the Danish reopening strategy (see Table 1, phase 2 and forward) do in fact align with the rankings suggested by our methodology (see Figure 2 and Figure 3).

Assessing both the health and economic implications of lockdown measures is associated with uncertainty. The process for the spreading of the virus and how it is affected by lockdown restrictions, physical distancing etc. is highly uncertain, and is continuously updated. Lockdown restrictions are a new type of economic policy, and hence there is no empirical work to draw on in assessing the effects of imposing or lifting such restrictions. Moreover, identifying the effects of lockdown measures in real time when consumer behavior, the global economy and many other things are changing simultaneously is extremely difficult. However, policy-makers have to make decisions in this uncertain environment, and the type of analysis and methods reported above give some guidance on the consequences of various policy options.

The many sources of uncertainty must be taken seriously, and this may call for a precautionary approach to designing reopening strategies. Opening too early or too late, obviously both have costs. But these costs are likely asymmetric, since an uncontrolled spread of the virus has dire consequences. This points to a gradual reopening strategy which in steps lifts lockdown restrictions.

Reopening is also associated with various ongoing restrictions (e.g. distance requirements between tables in restaurants), which may be of significant importance. There is a need to consider the details of such restrictions to assess their cost-benefit ratios. Moreover, the behavioral responses are important, and clearly reopening can move faster if behavior recommendations, such as physical distancing, hygiene, etc., are maintained and observed by the public despite the easing of more formal lockdown restrictions.

It is important to stress that the analysis and methods reported above do not include all aspects that are covered in Andersen, Schröder and Svarer (2020). The quantification reported above focusses on the short-run effects, but lockdown can have effects in the longer run also. Examples include the effects of closure of schools and various educational institutions. Even though distance learning is introduced, this may be an imperfect substitute, in particular for children with a weaker social background.

Finally, a number of further aspects are not reported here but discussed in the background report. This includes the wider business cycle implications, and in particular how export-oriented

firms are affected. The lockdown measures – in combination with various compensatory support schemes – have consequences for how the market mechanisms work, at least in terms of entry and exit of firms, which have lasting effects. The corona crisis may also speed up structural changes like a shift towards online shopping.

We suspect, that the process and the methodological choices presented reflect the considerations and dilemmas faced by other economists that conduct analyses for other countries at different stages of the Covid19 crises. Ultimately, the choices and practical implementations that we and other economist make in an attempt to assist policy decisions will have to be put to the empirical test. For example, at the time of writing, we simply do not know if the reduced form modeling of virus spread pressure that we have developed is a good enough approximation to actual developments of virus spread in the aftermath of reopening the economy. Similarly, the error that must stem from imposing pre-crises economic structures, such as weights for economic activity including input output tables, might be considerable. We recommend that these questions become the subject of future research.

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