Institute and Faculty of Actuaries

COVID-19 Report

General Insurance Pandemic Scenario Modelling: Constructing a Simplified Exposure-Based Realistic Disaster Scenario (RDS)

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Contents

Abstract

This paper provides a framework for general insurers to begin constructing pandemic scenarios in their planning and risk management work. It attempts to address the issue of GI exposures not being directly related to the case prevalence or death toll caused by a pandemic but rather the political and economic consequences of it. We propose a methodology here for how to start building a pandemic Realistic Disaster Scenario (RDS). This is achieved by assessing and evaluating the aggregates exposed by country and economic sector across different lines of business in the insurer's portfolio.

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1. General Insurance (GI) Pandemic Scenario Modelling Methodology

1.1. Introduction

This paper provides a framework for general insurers to begin constructing pandemic scenarios in their planning and risk management work. It attempts to address the issue of GI exposures not being directly related to the case prevalence or death toll caused by a pandemic but rather the political and economic consequences of it. We propose a methodology here for how to start building a pandemic Realistic Disaster Scenario (RDS). This is achieved by assessing and evaluating the aggregates exposed by country and economic sector across different lines of business in the insurer's portfolio.

The proposed methodology starts by grouping and ordering different countries and economic sectors for how exposed they are to the pandemic based on COVID-19 data. This process is then used to assign damage factors to different policy limits accumulated in the insurer's portfolio. Damage factors here are defined as percentages to be multiplied by limits of coverage to describe the proportion of the limit that will become loss if the pandemic RDS were to occur. The total portfolio RDS value is then defined as the resulting aggregated losses from each policy. We provide a simple RDS example in section 5.

Using evidence deduced in this paper that governmental early response to the COVID-19 pandemic was a good proxy for effective disease containment we were able to evaluate country risk. We grouped countries by governmental response time to enable the construction of country damage factors by group. Similarly, we used economic sector survey data on the impact of site closures and profits decline experience during COVID-19 to assess pandemic impact by sector. We ordered economic sectors by riskiness.

Here we would like to emphasise that it is not the exact results deduced in this paper that should be of interest to insurers but rather the approaches used. Each insurer may apply their own modifications to the proposed methodology depending on their portfolio construction, sectors operated in and attitude to risk. Moreover, this approach is only the starting point and may require many enhancements. We discuss those in section 6: Limitations of Analysis and Recommendations for Further Work.

1.2. Rationale for RDS Methodology

General insurers' exposures to a pandemic are a function of the political and economic implications of the pandemic. This was experienced most markedly through COVID-19 lockdowns and social distancing policies imposed by governments. These governmental policies triggered endless business interruption claims. Businesses were unable to continue to operate during lockdown periods and subsequent periods of social distancing policies. Their supply chains were disrupted causing their profitability and liquidity to suffer and some became insolvent. However, some sectors of the economy were impacted more than others during the pandemic. Moreover, smaller companies tended to operate more in sectors that were harder hit by COVID-19 like accommodation and food, arts and recreation and construction[1].

Unlike natural catastrophes, pandemics can benefit from human or governmental intervention to reduce their impact. Effective early governmental intervention is key to addressing this problem. The Ebola outbreak of 2014 had clearly demonstrated that early intervention can stop the virus from spreading[2]. For COVID-19, many countries that responded early with effective health and containment measures experienced lower case spread. For example, South Korea[3] and many Sub-Saharan African countries[4]. These countries deployed early, strict and effective contact tracing and

[1] https://www.bankofengland.co.uk/bank-overground/2020/how-has-covid-19-affected-small-uk-companies

[2] https://www.nationalgeographic.com/news/2014/10/141024-ebola-nigeria-outbreak-lessons-virus-health/

[3] https://ourworldindata.org/covid-exemplar-south-korea

4 https://www.independent.co.uk/voices/africa-test-and-trace-covid-b1774982.html

testing policies. They also may have benefitted from previous experience with other outbreaks.

The expectation was that effective and timely responses for COVID-19 were more likely to be adopted by developed richer nations. This was not necessarily the case. Interventions to combat the spread and the timing of those interventions in the USA and the UK were perceived to have been made politically rather than based on the science provided[5]. Moreover, there was also no clear evidence of a learning process by these two governments evidenced by their significantly larger second peaks of COVID-19 cases in the autumn of 2020.

1.3. Assumptions

Therefore, we make the following deductions from the arguments above and use those deductions as assumptions to underpin our methodology in this paper:

1. That assessing and quantifying a pandemic scenario for GI companies is a function of understanding country and sector exposures accumulated (amongst other factors)
2. That governments who respond early to a pandemic can limit spread and economic damage
3. That historical governmental actions under COVID-19 maybe a good guide or starting point to what countries may do in future
4. That different sectors of the economy are more or less sensitive to a pandemic when it comes to their business continuity
5. No matter the exact nature of the pandemic, an RDS process should start with identifying how exposures within the portfolio should be treated
6. That economic sector impact maybe generalised across countries for our simplified model in this paper. Here we use UK data on sector impact.

2. Data Sources Used

To construct and evaluate the proposed framework we use the following data:

1. Containment and Health Index Timeseries: Part of the Oxford Government Response Tracker (OxCGRT) Index timeseries for COVID-19 governmental response
2. Johns Hopkins University COVID-19 cases (infections) timeseries[6]
3. World Bank indicators' world population data as at 2019 by country[7]
4. UK Business Impact of COVID-19 Survey (BICS) results – UK Office for National Statistics

Items 1-3 will be used to evaluate country risk whilst item 4 will be used to evaluate economic sector risk.

2.1. The Oxford Government Response Tracker

''The Oxford COVID-19 Government Response Tracker (OxCGRT) systematically collects information on several different common policy responses that governments have taken to respond to the pandemic on 18 indicators such as school closures and travel restrictions.

OxCGRT collects publicly available information on 18 indicators of government responses. Eight of the policy indicators (C1-C8) record information on containment and closure policies, such as school closures and restrictions in movement. Four of the indicators (E1-E4) record economic policies, such as income support to citizens or provision of foreign aid. Six of the indicators (H1-H6) record health system policies such as the COVID-19 testing regime or emergency investments into healthcare.

The data from the 18 indicators is aggregated into a set of four common indices, reporting a number between 1 and 100 to reflect the level of government action on the topics in question.''

[5] https://time.com/5861697/us-uk-failed-coronavirus-response/

[6] https://data.humdata.org/dataset/novel-coronavirus-2019-ncov-cases

[7] https://data.humdata.org/dataset/world-bank-indicators-of-interest-to-the-covid-19-outbreak

For more details on calculation methods of OXCGRT please see Index mythology Version 3.3[8]

We will restrict our analysis to the Containment and Health Index Components of the OxCGRT. Our main interest here is the date(s) these containment and health measures began in each country rather than the evaluation of the index itself.

''A containment and health index (combines 'lockdown' restrictions and closures with measures such as testing policy and contact tracing, short term investment in healthcare, as well investments in vaccine)'' [9]. Components of the Containment and Health Index are:

Closure and Containment Measures

Indicator	Measure
C1	Schools closing
C2	Workplace closing
C3	Cancelled public events
C4	Restrictions on gatherings
C5	Close public transport
C6	Stay at home requirements
C7	Restrictions on internal movements
C8	International travel controls

Health Measures

Indicator	Measure
H1	Public information campaigns
H2	Testing policy
H3	Contact tracing
H4	Emergency investment in healthcare
H5	Investment in vaccine
H6	facial covering

2.2. UK Business Impact of COVID-19 Survey (BICS) Results

The business impact of COVID-19 survey results are collected every two weeks by the Office of National Statistics in the UK. We have used the published results with reference period of 19th of October to the 1st of November 2020 and a survey close date of 14th of November 2020. These dates coincide with the tightening of governmental movement restrictions in the UK due to the second wave of COVID-19. The survey captures business responses on how their turnover, workforce, prices, trade and business resilience have been affected in the two week reference period. The survey was sent to 39,000 business in the UK with a response rate of 26.8%. Results are recorded regionally and by sector. Typically responses are weighted by count of respondents or by employment levels[10].

Survey Main Topics Covered:

- Trading status
- Site closures
- Financial performance
- Export/import impact

[8] https://github.com/OxCGRT/covid-policy-tracker/blob/master/documentation/index_methodology.md

[9] https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker

[10] https://www.ons.gov.uk/economy/economicoutputandproductivity/output/datasets/businessimpactofcovid19surveybicsresults

- Access to goods
- Price bought/sold
- Demand levels
- Stockpiling/storage
- Capital expenditure
- Government grants
- Financing
- Redundancies
- Cashflow
- furlough
- Business confidence
- Reliance on hospitality sector
- Brian drain

Details on weighting methodology are available in the Business Impact of Coronavirus (COVID-19) Survey: Preliminary Weighted Results[11].

Responses we were particularly interested in in this paper were to the following question:

1. **Are you expecting to temporarily or permanently close any sites in the next two weeks?** Results provided were percentages of those businesses that responded with yes to having temporary or permanent site closures in each sector (weighted by number of respondents). For example, 5.9% of those in the construction industry answered yes.

2. **How has the coronavirus (COVID-19) pandemic affected profits, compared with normal expectations for this time of year?** Results provided are aggregated across those who responded saying their profits have decreased by up to 20%, 20% to 50% and more than 50%. For example, 73% of accommodation & food sector respondents experienced profit decline whist 42% of manufacturing sector respondents experienced a profits decline.

Item 1 of data maybe more useful for business interruption GI exposures whilst item 2 maybe more useful for loss of profits type exposures. Many other responses could be analysed to aid assessment of individual GI exposures. For example, for Marine Cargo or Trade Credit insurance lines' pandemic exposures, responses to trade related questions could be used for the different sectors like responses on imports, exports, stockpiling and trading status.

3. Analysis 1 – Country Analysis by Early Intervention

We wanted to understand the relationship between governmental response timing and COVID-19 spread. We conducted the following calculations:

Response Time from Case 1: We first measured for each country in our dataset the difference (in days) between the first case of COVID-19 infection being recorded and the first set of governmental intervention being recorded in the Containment and Health Index. This calculation is used to indicate which countries responded early or late. A negative number would indicate a government took action to contain the spread of COVID-19 before they recorded their first confirmed case of infection. A positive number indicates they responded after the first case was confirmed in the country in question. The method here does not distinguish between types of governmental response recorded as long as it is concerned with health measures or containment measures, both considered to be active steps to limit the spread.

COVID-19 Cases (Infections) per 100,00 of Population: World Bank population by country data is used against total case count from the Johns Hopkins infection (cases) by country timeseries to deduce COVID-19 cases per 100,000 of population per country. Total case count is final case count by country as at 16th of November 2020.

3.1. Analysis 1 Results

[11]https://www.ons.gov.uk/businessindustryandtrade/business/businessservices/articles/businessimpactofcoronaviruscovid19survey/preliminaryweightedresults

We grouped countries into bands of COVID-19 Cases per 100,000 of Population to analyse the response time. The arithmetic average Response Times from Case 1 were recorded by group. The analysis included 165 countries. Cases per 100K of population increase as the group number increases (1-6)

	COVID-19 Cases Per 100K of Population			
Groups	**Lower Threshold**	**Upper Threshold**	**Average of Government Response Time from Case 1***	**Count of Countries in Band**
Group 1	-	25	**-47.7**	20
Group 2	26	50	**-37.7**	17
Group 3	50	250	**-28.0**	35
Group 4	251	1,000	**-26.4**	30
Group 5	1,000	3,000	**-24.6**	49
Group 6	3,000	8,000	**-20.6**	14

Note* Average Government Response Time from Case 1: The difference between date first Containment and Health Index was recorded in country X and the Date first confirmed case of COVID-19 was recorded in country X, summed across countries in the group

It is clear to see that the higher the case count band (group) the later the country responded to COVID-19 through containment and health measures to stop the spread. On average countries responded before they recorded their first case (negative numbers) however there are many within the data set that responded as late as 40 days after the first case was recorded.

The cases per 100K of population show less sensitivity to earlier governmental response. In group 1 countries that on average responded 47.7 days before their first case had only up to 25 cases per 100K of population. Responding ten days later in group 2 shows that the cases per 100K could double to 50. However comparing groups 4 and 6, a smaller delays in response (26.4 days compared to 20.6 days) can cause almost 9 times the cases per 100K (looking at the midpoints in bands for groups 4 and 6).

This could be considered evidence of the argument that earlier governmental response means significantly less spread. Especially when considering that there are outliers included in this data set, countries that have responded early and have nevertheless experienced enormous spread (mainly 3 countries in South America).

Looking at the countries in each group, wealth and socio-economic development do not seem to be deciding factors on the spread of COVID-19. From the top five highest income economies, UK, USA and France are in groups 5 and 6. Japan in group 3 responded earlier and may have benefitted from its previous experience of preventing SARS and MERS from spreading[12].

Given the above observations, we believe it may be reasonable to use the 6 group classifications to represent country pandemic risk as measured by governmental response timing. Whereby the higher the group classification for a country the higher the risk of disease spread. Assuming that COVID-19 experience to be a good guide to future pandemics.

3.1.1. Country Group Classification by COVID-19 Cases per 100K of Population Table

[12] https://time.com/5842139/japan-beat-coronavirus-testing-lockdowns/

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Burundi	Angola	Afghanistan	Albania	United Arab Emirates	Andorra
Benin	Brunei	Australia	Azerbaijan	Argentina	Belgium
Burkina Faso	Bhutan	Barbados	Bangladesh	Austria	Bahrain
China	Liberia	Central African Republic	Botswana	Bulgaria	Switzerland
Democratic Republic of Congo	Mozambique	Cote d'Ivoire	Canada	Bosnia and Herzegovina	Czech Republic
Fiji	Mauritius	Cameroon	Cyprus	Belarus	Spain
Cambodia	Malawi	Congo	Germany	Belize	Israel
Laos	Nigeria	Cuba	Estonia	Bolivia	Kuwait
Mali	New Zealand	Dominica	Finland	Brazil	Luxembourg
Mongolia	Rwanda	Algeria	Gabon	Chile	Moldova
Niger	Sudan	Egypt	Greece	Colombia	Panama
Papua New Guinea	Sierra Leone	Ethiopia	Guatemala	Cape Verde	Qatar
Solomon Islands	Somalia	Ghana	Guyana	Costa Rica	San Marino
Chad	South Sudan	Guinea	India	Denmark	United States
Thailand	Syria	Gambia	Iran	Dominican Republic	
Timor-Leste	Togo	Haiti	Jamaica	Ecuador	
Tanzania	Uganda	Indonesia	Kazakhstan	France	
Vietnam		Japan	Latvia	United Kingdom	
Vanuatu		Kenya	Morocco	Georgia	
Yemen		South Korea	Mexico	Honduras	
		Sri Lanka	Namibia	Croatia	
		Lesotho	Norway	Hungary	
		Madagascar	Nepal	Ireland	
		Myanmar	Philippines	Iraq	
		Mauritania	El Salvador	Iceland	
		Malaysia	Eswatini	Italy	
		Nicaragua	Trinidad and Tobago	Jordan	
		Pakistan	Tunisia	Kyrgyz Republic	
		Senegal	Turkey	Lebanon	
		Seychelles	Venezuela	Libya	
		Tajikistan		Lithuania	
		Uruguay		Monaco	
		Uzbekistan		Netherlands	
		Zambia		Oman	
		Zimbabwe		Peru	
				Poland	
				Portugal	
				Paraguay	
				Palestine	
				Romania	
				Russia	
				Saudi Arabia	
				Singapore	
				Serbia	
				Slovak Republic	
				Slovenia	
				Sweden	
				Ukraine	
				South Africa	

4. Analysis 2 – Sector Analysis by Site Closures and Profit Decline

Using the UK COVID-19 Business Impact Survey results, we wanted to risk-rate different economic sectors by the most site closures and profits decline experienced. This would mean ordering sectors by impact and then applying damage factors based on the order and magnitude of responses. However, we only show an example of how sector damage factors could be applied to policy limits as we consider the process of allocating figures to damage factors to be highly subjective and should be left to each individual insurers' own assessments.

As mentioned in the previous section, site closures maybe useful for risk-rating business interruption insurance coverage whilst profits decline experience maybe more useful for risk-rating loss of profits type insurance business. This analysis could be extended further to cover more insurance lines using other responses to the survey and applying the same or similar risk-rating methodology.

3.2. Analysis 2 Results

We present results ordered by sector. The highest percentage of respondents saying yes means the highest proportion of businesses within that sector that have experienced site closures or decline in profits. This corresponds to highest group number 14:

3.2.1. Site Closures Responses Ordered by Economic Sector Table

Group 1 - 14 (14 is Highest Site Closure Respondants)	Question: Are you expecting to temporarily or permanently close any sites in the next two weeks?	
	Sector	Answered Yes
1	Water Supply, Sewerage, Waste Management And Remediation Activities	1.4%
2	Information And Communication	2.1%
3	Transportation And Storage	2.3%
4	Manufacturing	3.0%
5	Professional, Scientific And Technical Activities	3.2%
6	Human Health And Social Work Activities	3.4%
7	Real Estate Activities	3.9%
8	Administrative And Support Service Activities	4.8%
9	Arts, Entertainment And Recreation	5.2%
10	Construction	5.9%
11	Education	9.8%
12	Wholesale And Retail Trade; Repair Of Motor Vehicles And Motorcycles	10.2%
13	Accommodation And Food Service Activities	25.2%
14	Other Service Activities	25.2%

3.2.2. Profit Decline Responses Ordered by Economic Sector Table

Group 1 - 14 (14 is Most Profit Decreased Respondants)	Question: In the last two weeks, how has the coronavirus (COVID-19) pandemic affected profits, compared with normal expectations for this time of year?	
	Sector	Profits have Decreased (Aggregated Responses)
1	Real Estate Activities	24.8%
2	Water Supply, Sewerage, Waste Management And Remediation Activities	28.5%
3	Information And Communication	29.6%
4	Transportation And Storage	32.4%
5	Construction	37.7%
6	Human Health And Social Work Activities	39.6%
7	Professional, Scientific And Technical Activities	40.6%
8	Manufacturing	42.2%
9	Wholesale And Retail Trade; Repair Of Motor Vehicles And Motorcycles	43.5%
10	Administrative And Support Service Activities	53.8%
11	Education	56.3%
12	Arts, Entertainment And Recreation	62.6%
13	Accommodation And Food Service Activities	72.5%
14	Other Service Activities	78.0%

The analysis shows that industries such as accommodation and food, wholesale and retail where highly impacted by site closures and decreased profits during the second wave of this pandemic. Service industries were the most impacted with group 14 being Other Service Activities for both categories of responses. Results of turnover shocks presented by the Bank of England by sector broadly support the findings of this survey, where sectors such as accommodation, food, arts and recreation, retail/ wholesale and other service industries were more impacted by COVID-19 than utilities (e.g. water supply) and information and communications[13].

These rankings could be used to assign damage factors to apply to insurance exposures that increase by group number and proportion of any sector impacted. For example business interruption exposure of a property policy of a manufacturing plant, group 4 on site closures' table represents relatively low site closure risk. This could mean a small sector damage factor is applied to the business interruption limit of coverage. The values used for the damage factor will be subjective taking into account that 3% answered yes to the question (in an overall range of responses from 1.4% to 25.2% across all sectors). However the order of impact by sector (1-14) would still be maintained.

This analysis of course assumes that sector impact in the UK is applicable to all countries but this analysis could be extended and modified to include similar statistics for other countries. The methodology of ordering sectors by impact will still be valid.

5. Realistic Disaster Scenario Methodology

We wanted to use the results of analyses 1 and 2 to create a simplified GI pandemic RDS. This is done by applying damage factors to the policy limits for the assumed insurance portfolio below. Each insurance policy is characterised by its line of business, country and economic sector of operations.

Insurance Portfolio				
Policy	**Country**	**Policy Type**	**Sector**	**Limit of Coverage $**
1	Japan	Business Interruption	Utilities: Water Supply	10,000,000
2	UK	Business Interruption	Accommodation and Food	10,000,000
3	China	Loss of Profits	Retail and Wholesale	10,000,000

We deduce subjective damage factors for both country and sector, making the distinction between sector impact on business interruption and loss of profits insurance policies in the portfolio. We define our damage factors here as a percentage multiplied by limits of coverage representing the potential loss due to the pandemic RDS. Damage factors are also multiplied by other damage factors in this example. Therefore the subjective characterisation of one type of damage factor may need to take into account the other type.

We rely on the groupings of countries and the order of impact by sector to come up with subjective damage factors. For example, a country in group 6 that has suffered very large COVID-19 spread will be expected to have a higher damage factor than one in group 1. The same logic applies to sector impact where accommodation and food sector is more highly exposed to loss than utilities' sector and hence the former gets a higher sector damage factor. We decided on Damage factors as follows:

[13] https://www.bankofengland.co.uk/bank-overground/2020/how-has-covid-19-affected-small-uk-companies

Country Damage Factor by Band of Cases Per 100K of Population			
	Cases Per 100K of Population		
Groups	Lower Threshold	Upper Threshold	Damage Factor Assumed
Group 1	-	25	1%
Group 2	26	50	2%
Group 3	50	250	5%
Group 4	251	1,000	10%
Group 5	1,000	3,000	30%
Group 6	3,000	8,000	50%

Countries in the portfolio have the following group classifications:

Country	Group
Japan	Group 3
UK	Group 5
China	Group 1

for economic sectors in the portfolio we come up with the following damage factors:

Sector Damage Factor by Industry (Subset)		
Survey Question	Sector	Damage Factor Assumed
Site Closure	Utilities: Water Supply	5%
Site Closures	Accommodation and Food	50%
Lost Profits	Retail and Wholesale	25%

Damage factors are multiplied by each other and by the limits to give individual policy pandemic loss amount. For business interruption policies we use site closures damage factors and for loss of profits policy we use lost profits damage factors. The loss to policy results are summed to give the potential RDS loss for this entire portfolio.

$$\text{Portfolio RDS Loss} = \sum_{i} \text{Loss to Policy}_i$$

$$\text{RDS Policy}_i = \text{Limit of Policy}_i \text{ X Damage Factor (Country)}_i \text{ x Damage Factor (Sector)}_i$$

5.1. Example: RDS Loss to Policy 1

Japan is in country group 3 with country damage factor 5%. Business interruption limit of $10m in Utilities Water Supply's sector. Hence site closure damage factor for that sector is 5%

Therefore RDS Loss to Policy 1 is = $10m x 5% x 5% = $25K

5.2. Portfolio RDS Loss

Following the same calculations above in the example the loss to portfolio is the aggregate of all policy losses:

Insurance Portfolio					
Policy	Country	Policy Type	Sector	Limit of Coverage $	Loss to Policy
1	Japan	Business Interruption	Utilities: Water Supply	10,000,000	25,000
2	UK	Business Interruption	Accommodation and Food	10,000,000	1,500,000
3	China	Loss of Profits	Retail and Wholesale	10,000,000	25,000
				Loss to Portfolio	1,550,000

Hence this methodology assumes a pandemic portfolio RDS of $1.55m for the scenario in question.

These results are illustrative and may require additional damage factors to give more realistic estimates. Damage factors may also vary given assumed severity of pandemic scenario assumed and subjective judgement. They could also be deduced using scientific logic and could be less subjective than what we have here. However the overall concept may still be applicable to scenario construction process using country and sector as risk factors.

6. Limitations of Analysis and Recommendations for Further Work

This work can be viewed as a starting point to constructing pandemic GI scenarios based on the experience of COVID-19 to date. During this pandemic governmental interventions and policies became the primary drivers of risk for GI exposure to COVID-19. This was mainly due to lockdowns and resulting suppression of economic activity. Countries adopted different interventions but it was made clear in our analysis that countries that responded earlier had lower spread. The Pandemic also proved that socio-economic might did not necessarily mean better outcomes for the spread of disease and economic consequences, especially if governmental containment and health measures come too late. COVID-19 did however impact different sectors in the economy differently as demonstrated by the UK Business Impact Survey results extracted. Therefore we feel that country risk (as measured by timing of government intervention), and economic sector risk are key to evaluating the size of a GI pandemic RDS.

This analyses in this paper have many limitation. They assumes that the next pandemic of note will resemble COVID-19. This may or may not be true. Consideration of the impact of other diseases maybe useful here, for example how would the methodology here be adjusted when looking at haemorrhagic fever type pandemics like Ebola? It is also important to plan more than one scenario varying by size of impact for example a regional outbreak versus a worldwide outbreak.

The analysis assumes that the past is a good guide to the future in terms of governmental response to COVID-19. This may not be true if governments undergo changes due to elections or due to political unrest. To improve the credibility of the analysis of governmental response timing, one potential future enhancement could be to overlay country response timing risk-rating in this analysis with results from a political risk index capturing on-going changes in the country. Another useful measure to overlay would be a country pandemic response preparedness index capturing what was learnt by these countries from COVID-19.

This analysis could be extended by type of GI exposure. For example trade related responses to UK Business Impact Survey could be used to risk-rate Marine Cargo or Trade Credit insurance exposures. There are however other factors influencing GI pandemic exposures that need to be considered, even beyond covering other lines of business. Country and sector risks need to be adjusted for the globalised nature of modern economies. A measure of a country's economic dependency on others economies should also be considered in terms of trade, commodity prices, input materials, tourism, and other economic factors.

Another useful enhancement here is to consider looking at sectors by company size. COVID-19 has shown that smaller business were disproportionately impacted by the pandemic. It may also be a useful exercise to look at other countries' similar reports to understand COVID-19 sector impact as the UK's experience may not be applicable to many other countries.

The reference data used in this paper specifically the OxCGRT and the UK Business Impact of COVID-19 Surveys have a wealth of information within them that could be used and adapted for GI pandemic scenario modelling work. Additionally the Bank of England's Monetary Policy Report on Financial Sustainability in 2020[14] also provide useful references for furthering the analysis of economic sector impact. We hope the data and proposed methodology in this paper can pave the way for further work on pandemic scenario modelling.

[14] https://www.bankofengland.co.uk/report/2020/monetary-policy-report-financial-stability-report-august-2020