Discovering Business Recovery Strategies and the Role of Governmental Policies through Analysis of Facebook Business Activity Trends during the COVID-19 Pandemic

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1 Introduction

The COVID-19 pandemic left an indelible mark on the world. It reshaped economies, challenged businesses and required unprecedented responses. To look at the impact of the COVID-19 pandemic on businesses worldwide, I will be making use of two datasets; the Facebook Business Activity Trends dataset (FBAT) [17] and the Oxford COVID-19 Government Response Tracker dataset (OxCGRT) [12]. The former captures the change in business activity globally during the pandemic and its aftermath while the latter captures the response of governments through policies released globally during the pandemic. The aim of this analysis is to uncover the strategies that aided in the recovery of some businesses and to also investigate the pivotal role that governmental policies play in crises like the COVID-19 pandemic.

To achieve this, the following objectives will be pursued: understanding the key metrics in the FBAT dataset, assessing the quality of data captured in the FBAT dataset, analyse the timeseries data for specific countries (5-6 countries which are chosen to be as representative as of the global situation as possible), and identify the effects of policies on business trends in those chosen countries through the integration of the OxCGRT dataset.

2 Methodology

2.1 Dataset Overview

To analyze the impact of the pandemic on businesses, we made use of the Facebook Business Activity Trends (FBAT) dataset in synergy with the Oxford COVID-19 Government Response Tracker dataset (OxCGRT).

2.1.1 Facebook Business Activity Trends dataset

This is a dataset curated by Data for Good at Meta. It looks captures the change of that daily posting patterns of business pages around the world on Facebook with regards to their activity before the pandemic began. The data captures a pandemic period which starts from the crisis data, March 1st 2020, till November 29th 2022. For the COVID-19 pandemic, it captures a period of 365 days before the crisis date as its baseline period, this means that only business which had active Facebook Business pages 365 days prior to the crisis date we're included during the data collation. The data is collated on a 'cell' basis i.e., it looks at a particular business sector (business vertical) in a particular country [16].

In this dataset, business activity is quantified using two metrics; activity quantile and activity percentage. Activity quantile captures the change in the daily posting behaviour of businesses on Facebook during the pandemic as compared to their precrisis behaviour. While activity quantile measures the daily performance of business relative to the baseline period, activity percentage focuses on its weekly performance. Activity percentage bases its comparison on the basis of the business' normal weekly activity. Anomalous behavior as compared to the baseline period can be

seen when the activity quantile significantly deviates from 0.5 or the activity percentage significantly deviates from 100 [16].

2.1.2 Oxford COVID-19 Government Response Tracker dataset

The Oxford COVID-19 Government Response Tracker (OxCGRT) dataset was captured by the Blavatnik School of Government at Oxford University. It is a comprehensive compilation of government responses from to the COVID-19 pandemic, comprising 24 policy indicators grouped into four categories: containment and closure policies (C), economic policies (E), health system policies (H), and vaccination policies (V) and it spans from 2020 to 2022. It captures data on a national jurisdiction level and also on subnational jurisdiction levels. To simplify the complex dataset, four indices condense the information into single numerical scores, allowing for a comparative assessment of government responses. These indices include the overall government response index, containment and health index, stringency index, and economic support index, each scored between 0 to 100. However, they do not evaluate the effectiveness of the policies implemented but only help in the comparison between nations of policies implemented. The data is split amongst different csv files depending on the use case [19].

2.2 Approach

This analysis was done on Python 3.10.9 using jupyter notebook. The FBAT dataset was gotten of the Facebook Data for Good website [1] and it came in 1004 csv files, one for each day starting from March 1st 2020 up until November 29th 2022. These files were read into Python and combined into one csv file using the pandas [5] and the glob [3] library. The combined dataset contained a total of 2,396,549 observations and 12 variables. For the FBAT dataset, only the country names (gadm0_name) were included, the entire cells in the subregions variables (gadm1_name and gadm2_name) were empty. There are 12 business verticals recorded in this dataset; Business & Utility Services, Grocery & Convenience Stores, Home Services, Lifestyle Services, Local Events, Manufacturing, Professional Services, Public Good, Restaurants, Retail, Travel and 'All' (which captures all businesses including the ones not included in the previous categories).

Following the advice of the authors [3], for this analysis, the activity quantile was used instead of the activity percentage due its robustness to outliers (businesses in a particular business vertical which post a lot) and its numerical stability. Due to the limited scope of this project, analysis was performed on United Kingdom, Brazil, Nigeria, New Zealand, Kyrgyzstan and Sweden. The first 5 countries were chosen from different continents to be as representative of the global situation as much as possible, while Sweden was chosen due to its relaxed approach with minimal restrictions.

Working with the OxCGRT dataset, we focused only on the containment and closure policies which were issued in our chosen countries for everyone i.e., both vaccinated and unvaccinated. This subset of the data was captured for 8 kinds of containment and closure polices (School closing, Workplace closing, Cancel public events, Restrictions on gatherings, Close public transport, Stay at home requirements, Restrictions on internal movement and International travel controls) with ordinal values ranging from 0 to 2 (3 or 4), each representing the strictness of the policies implemented. For each of the 8 kinds of containment and closure policies, there were associated variables which contained notes which captured the news around that policy that was changed which came in handy during analysis. Although the timeline of this dataset spanned past the date of the FBAT dataset, this analysis was limited to only the period which the FBAT dataset covers.

3 Analysis

3.1 Basic Stats & Metrics

3.1.1 Number of countries/regions mentioned in the FBAT dataset

The data is only broken down on country level (gadm0) and there are 220 countries captured in this dataset. There is no data for regions (gadm1) and subregions (gadm2).

3.1.2 Total number of dates available for each country, in terms of type of business. A description of the missing values/duplicates contained and plans on dealing with them if any

The dataset captures data from March 1st 2020 to November 29th 2022 which is a time period of 1004 days. For each of the 220 countries, there are a set of 1004 unique dates with no missing data. However, when looking at the count of dates per business vertical in each country, there appears to be missing values due to a few of the countries not have all 12 business verticals which is probably due to the fact that those business sectors are underrepresented on Facebook Business. Nevertheless, for all the 220 countries, all the business verticals which were captured for that particular country each have 1004 unique dates save for the 'Retail' business vertical in Turkmenistan which just has one date, July 10th 2020 but this can be ignored since my scope doesn't cover Turkmenistan. There are also no duplicates in this dataset.

3.1.3 How are the key metrics in the FBAT dataset, activity quantile and activity percentage, calculated?

The activity quantile metric assesses business activity within country(polygon)-business vertical combinations (referred to as cells). The process begins by comparing the daily post count of each business page during the crisis period with its baseline distribution, resulting in an individual page activity "mid-quantile." This mid-quantile, calculated as $q_i(t) = \frac{1}{2}[P_i(x_i(t)) + (P_i(x_i(t)) + 1)]$, averages the daily post count relative to the baseline, smoothing the empirical cumulative distribution function (eCDF). Aggregating these individual page activity mid-quantiles within each cell creates a cell-specific daily activity quantile. This aggregate measure signifies the cell's business activity relative to the baseline period. Values near 0.5 represent pre-crisis-like behavior, while significant deviations from 0.5 indicate abnormal activity levels. Notably, to address privacy concerns, data for cells with fewer than ten business pages are withheld.

The calculation involves several steps, including summing the mid-quantiles, shifting and rescaling to achieve a standard Normal distribution, adjusting for posting behavior correlation, and performing a probability integral transform. Ultimately, the 7-day average of the transformed time series smooths daily fluctuations and provides a metric signifying anomalous activity levels without bias towards highly active businesses [3].

In contrast, the activity percentage metric measures the 7-day rolling sum of total activity as a percentage of the average weekly baseline activity. It divides the 7-day rolling sum of total posts during the crisis by the average of the 7-day sum of total activity every Monday within the baseline period and multiplies the result by 100. Values around 100 are considered normal while significant deviations indicate abnormal activity. While this metric is straightforward, it's sensitive to businesses with high posting frequency, potentially giving misleading results. Additionally, its stability diminishes with low post counts. Despite it being highly interpretable, the activity percentage metric might not be the best choice due to its sensitivity to highly active businesses and instability with low post counts [1].

For this analysis, the activity quantile is preferred over the activity percentage as it provides a nuanced assessment of abnormal activity levels across businesses, avoiding bias towards highly active ones. It maintains stability even with low post counts, ensuring a fair evaluation of anomalous activity levels and representing a more suitable metric for the analysis at hand [1].

3.1.4 Business activity in United Kingdom, Brazil, Nigeria, New Zealand, Sweden and Kyrgyzstan during the pandemic*(You can talk about why later)*

For my analysis, I have chosen the United Kingdom (UK), Brazil, Nigeria, New Zealand, Sweden and Kyrgyzstan to represent diverse global pandemic landscapes. Also, due to the limited scope of this analysis, I have chosen to focus on 3 business verticals; Grocery & Convenience Stores, Restaurants and "All".

Overall, in Figure 1, we can see that for Brazil, Nigeria, New Zealand and Sweden the activity quantile trend for Grocery & Convenience stores and Restaurants closely follow that of the 'All' category as this can be seen as the green linegraph being in the middle while the rest are above or below it with little to a bit significant (Sweden) deviation at some time periods. While for UK, although the 'All' plot lies in-between the other line graphs, there is a significant difference between them at certain time periods in 2020 to 2021. Also, for Kyrgyzstan, it appears that the

other 2 business verticals performed worse than the 'All' from the beginning of 2021 up until the November 2022.

Looking at the plot, we can see the times in which the performance of the business verticals in each country dipped and performed below the baseline. What's worth noting is that all countries experienced a significant dip in their activity quantile for the 'All' business vertical in early January 2021 and early January 2022. Looking at the 'All' business vertical once more, nearly all countries display a relatively stable to low decreasing trend in the activity quantile metric. The exceptions are Nigeria which displayed the highest decreasing trend in activity quantile for even all its selected business verticals and Kyrgyzstan which displays decreasing trend although it is not as steep as that of Nigeria.

Figure 1: Plot showing the business activity (measured using activity quantile) during the pandemic across 3 business verticals (Grocery & Convenience Stores, Restaurants and "All") for Brazil, United Kingdom, Nigeria, Kyrgyzstan, New Zealand and Sweden

3.1.5 Deep dive into the trends data for each country, looking for general trends, seasonality and unexplained variations

For a deep dive into the activity quantiles for our selected countries, I have chosen to focus on just the 'All' business vertical since it tries captures all the business sectors which also makes our analysis a lot simpler [3]. Time series data such as the one were dealing with most times has 4 components; general trend, seasonality, cyclical movements and unexplained variations. As a result, our time series can be represented as $x_i = f_t + s_t + c_t + e_t$) which is the sum of those components where t is the time of observation. Our objective then is to decompose the time series into its constituents and develop mathematical models for each [20]. My interest lies in finding out if there's any seasonal variation as the data only spans 2 years and as such, the cyclical movements can't be analyzed due to it requiring a longer time period. In order to observe the seasonal effects on the activity quantile over the time period, we would need to observe the overall trend of the

data, this means modeling our activity quantile as a regression against time. This model (which is represented as a trend line as shown in Appendix A) can then be used as our prediction of the long run movement of the activity quantile i.e., the general trend, while the residuals can be analyzed for the remaining 3 components [7]. All this was done using scikit-learn's standard scaler from its *preprocessing* module [7] to standardize the dates (which were represented as integer values) and its linear regression model in *linear_model* module [6] to model activity quantile against time as seen in Figure 2.

```python
# getting subset of only 'All' business vertical
seasonality_analysis = df_countries_busvert.query("business_vertical == 'All'")
```

0.0s Python

```python
pred_vals_arr = [] # empty list to contain all the predictions for activity quantile

# standardizing x values which would be represent days since datetime format can be
# in LinearRegression
scaler = StandardScaler()
X = np.arange(seasonality_analysis.ds.nunique()).reshape([-1,1])
scaler.fit(X)
stand_X = scaler.transform(X) # standardized X values

# perform linear regression on the timeseries data for each country
for i in choice_countries:
    trend_model = LinearRegression()
    trend_model.fit(stand_X,
                    seasonality_analysis.query("gadm_name == @i")['activity_quantile'].values)
    pred_vals = trend_model.predict(stand_X) # get the predicted activity quantile given the dates
    pred_vals_arr.append(pred_vals)

# convert pred_vals_arr to df
pred_vals_df = pd.DataFrame(pred_vals_arr).T
pred_vals_df.columns = choice_countries
```

0.0s Python

Figure 2: Code snippet showing how the general trend of activity quantile for each country was modelled against time. *df_countries_busvert* is a subset of the data which contains only activity quantile for the chosen countries and business verticals. *choice_countries* is a list of the chosen countries

Once the predictions were gotten, the residuals were then derived by getting the difference between the actual values of the activity quantiles and the predictions. The plot of residuals against time then results in a detrended time series data which can be further analyzed to see the effect of seasons and unexplained variations (Figure 3).

Figure 3: Run sequence plot of residuals which shows the detrended activity quantile for the 'All' business vertical plotted against time for all 5 chosen countries

Further analysis of seasonal patterns

In general, on a quarterly basis, there is much of a pattern because our boxplots show a very high variation for each quarter with most having outliers (Figure 4). However, it is noticeable that for the first quarter, there is a lot of variation in the activity quantile especially in the United Kingdom. This data would need to be looked at on a monthly level to uncover any reoccuring patterns.

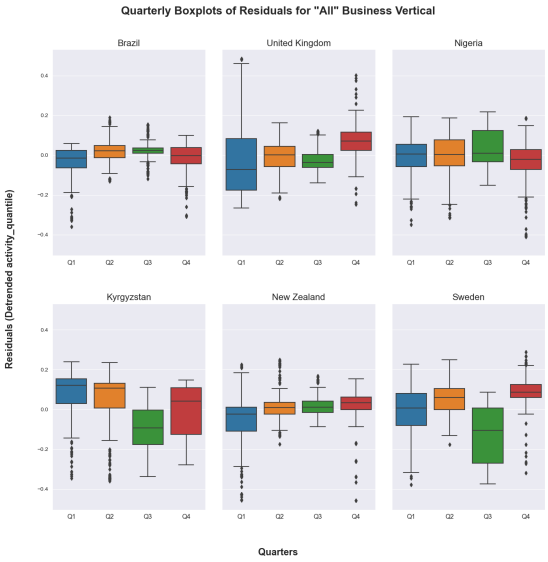

Figure 4: Quarterly boxplot of residuals for all 5 chosen countries for "All" business vertical

A monthly grouping of the residuals, we can see lesser variance in some of the boxplots (Figure 5). For Brazil, the towards the end of the year and the first month of the following year, tends to be more variable as more fluctuations in residuals were recorded there. The middle of the year, especially the summer months, June to August have fewer fluctuations with a median at 0 with August have some days were it performed better than predicted. For the United Kingdom, it can straightaway be noticed that the month of March was highly volatile. We can also notice a slight increase in residuals, starting of low with a median of close to -0.2 in January, slowly increase, even though still variable till July where it experienced a drop in quality in August and then picking up gradually and have a median around 0.1 in December, although November displayed a lot of outliers much higher, before it experiences a huge drop in January.

The plot for Nigeria has a lot of variance although the medians for each month reside around 0 but the range of fluctuations in November was low with no outliers. For Kyrgyzstan it also appears to be highly variable with the month of April having the highest variance. However, the months of February and December seems interesting as it has low variance and mean above 0. The month of March although having less variance its boxplot, it still has a lot of outliers extending up until around -0.3.

New Zealand seems a lot interesting as most of the months, except for January, displayed less variance in the residuals. We can see it rising from a low point of median -0.2 in January to values which center around 0 throughout the year before it reaches November which is a highly volatile month with a lot of outliers below 0, extending up until -0.4. It then experienced a huge drop in January. For Sweden, The first 6 months of the show and increase in residuals from a low median of around -0.1 in January to a bit above 0 in June before falling in July to a value of around -0.3. Slowly rising in August, the next 3 months have a low variance with residuals around 0.1. It reached a high median 0.2 in November although that month was highly volatile before drastically dropping the flowing year.

From the plots, we can see the last quarter, although high, tends to be more volatile before experiencing a drastic drop the following year in January. Also, some times, there tends to be a slight drop in the middle of summer (July and August). When looking at the daily plot of residuals (Appendix B), there is no pattern to be noticed. This is because of the 7-day average that was taken during the calculation of the activity quantile metric in order to smooth daily fluctuations [3].

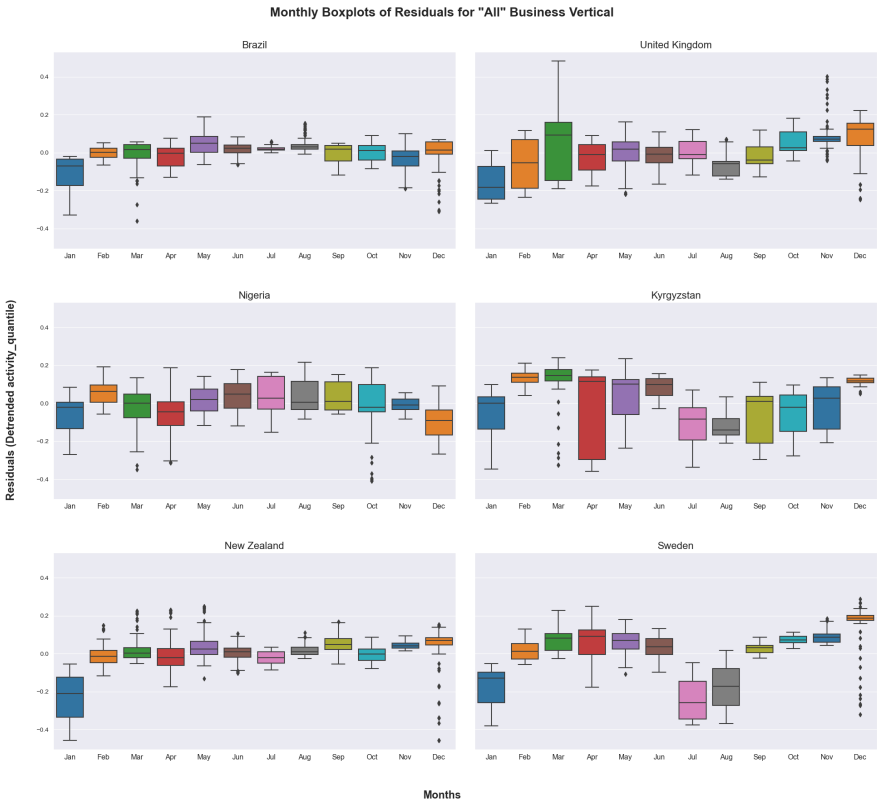

Figure 5: Monthly boxplot of residuals for all 5 chosen countries for "All" business vertical

3.1.6 Please choose two days and visualise different countries/states (depending on the gadm_level of the dataset) with the business level (preferably using colormaps), in those two days.

As was noticed in the monthly box plots, there tends to always be a volatile peak around November-December before a drastic fall at the beginning of January the following year (Figure 5). For this analysis, we would look at the change in business levels for all countries from the peak in November 2021 to the valley in January 2022. Getting the maximum and minimum activity quantile within that time period results in the dates of interest being 2021-12-24 (just before Christmas) and 2022-01-08 (a week after New Year's day) (Figure 6).

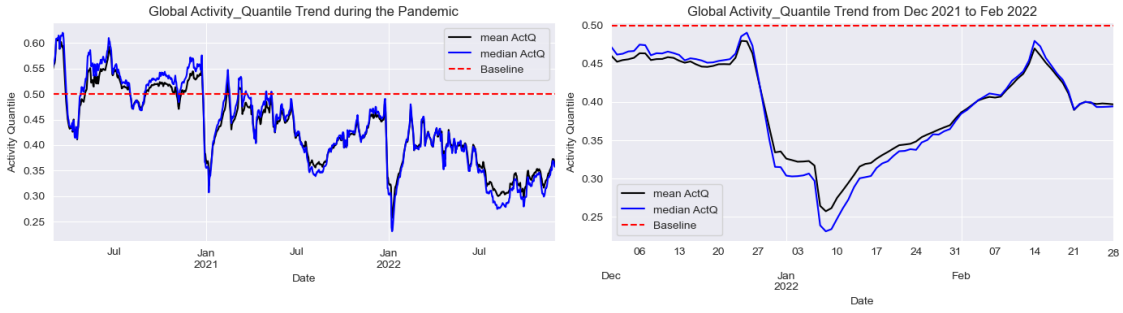

Figure 6: Left plot shows the global activity quantile for all business verticals plotted against time. Right plot shows the global activity quantile trend from December 2021 to February 2022. Aggregation of activity quantile was done my taking the mean (black) and median (blue).

Generally, looking at the plot for 'All' business vertical for December 24th 2021 in Figure 7, we can see that majority of the countries at that experienced business levels relative to the baseline except for countries in North America (Mexico and United States), countries in the South of Africa and Australia. During the drastic drop in business activity on January 8th the following year, those

countries along with others worsened with Australia having one of the worst performance along with Kazakhstan which surprisingly had a much better activity quantile on the 24th of the previous month. It is worth noting that Libya seems to show an outstanding performance on both days and for all 3 business verticals plotted. Algeria also follows suite although its performance is not as outstanding as Libya's.

For the Grocery & Convenience Stores, on December 24th 2021, nearly all countries experience high business activity except for Nigeria, Kyrgyzstan and some Southeast Asian countries which performed poorly. However on the 8th of January 2022, nearly all countries experience a drastic drop in business activity except for Libya and Algeria in North African and also most countries which lie on the equator.

For restaurants, we can see that it had the worst business activity for our selected business verticals in the peak of December. Unsurprisingly it had the worst performance during the low season of January. Nearly all countries have their restaurants experiencing a poor performance except for Libya, Algeria, Mali, Mauritania, Ethiopia and Turkmenistan

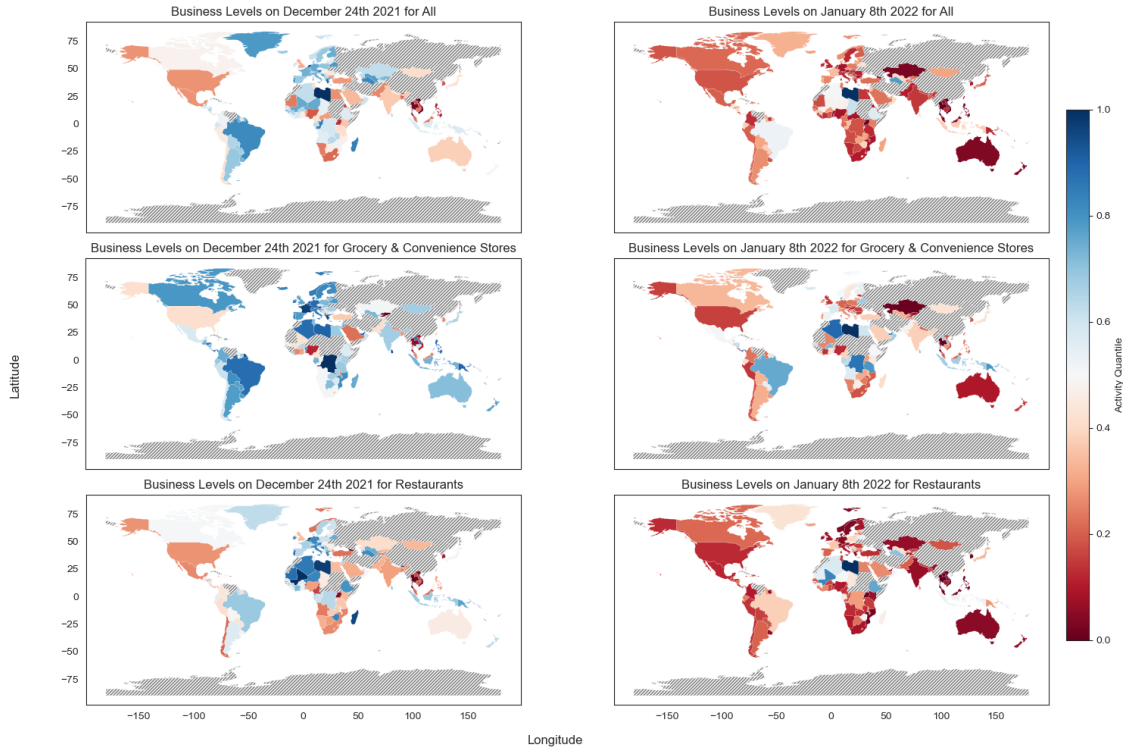

Figure 7: Change in business levels (activity quantile) from 24th December 2021 to 8th January 2020 for All, Groceries & Convenience stores and Restaurants for all countries. Hashed out countries have no data.

3.2 Events

For this section, the first question focused on a analysing the difference and similarity in business activity levels in the differenct business sectors while the last question focused on uncovering the effect on policies on business activity for the chosen countries. For interpretability, the 7-day moving average of activity quantile was gotten for each business vertical and plotted against time so as to smoothen out the daily fluctuations [7]. As seen in Figure 8, the smoothened out plot closely resembles the regular daily plot of activity quantile because it retains enough information whilst still removing irregular variations.

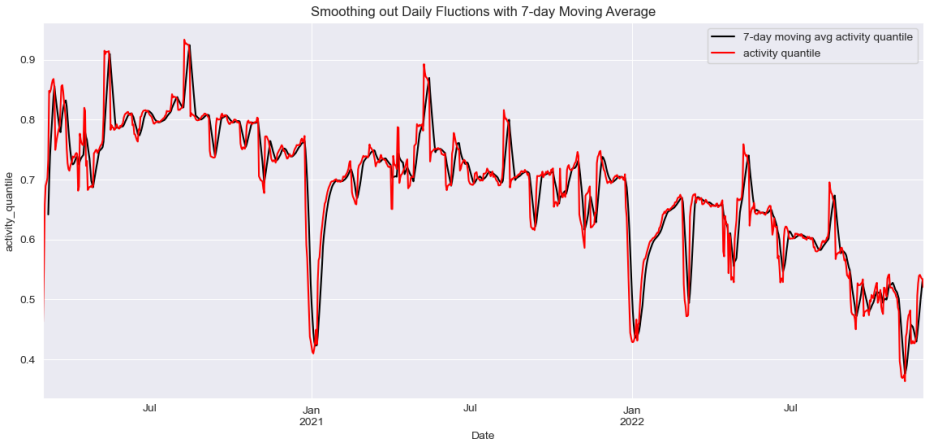

Figure 8: Smoothing out daily fluctuations in activity quantile by taking the 7-day moving average of activity quantile.

3.2.1 Analysis of changes in business trends across different business verticals for United Kingdom, Brazil, Nigeria, New Zealand, Sweden and Kyrgyzstan

Looking at the United Kingdom (Figure 9), we can see that it all business verticals performed below the baseline for most part of the time period. The worst performing business vertical is the Local Events as it had activity quantile between 0.0 to 0.2, following after it, unsurprisingly is the Travel sector. Amongst the poor performance in the United Kingdom, the Grocery & Convenience Store business vertical and the Public Good vertical had the least poor performance. However, from the plot, it can be observed that at specific points in time, almost all business verticals experienced peaks and dips together, with the latter closely following the former. The most noticeable peak of around 1.0 is that around April 2020 because after that, almost all business sectors experienced a sharp drop to a valley of 0-0.4. Two other peak-sharp-dip periods are important and they occur around the end of the year and the beginning as can be noticed in the plot. Also, it seems that around August for both years, business activity drops a before peaking up again in the following months.

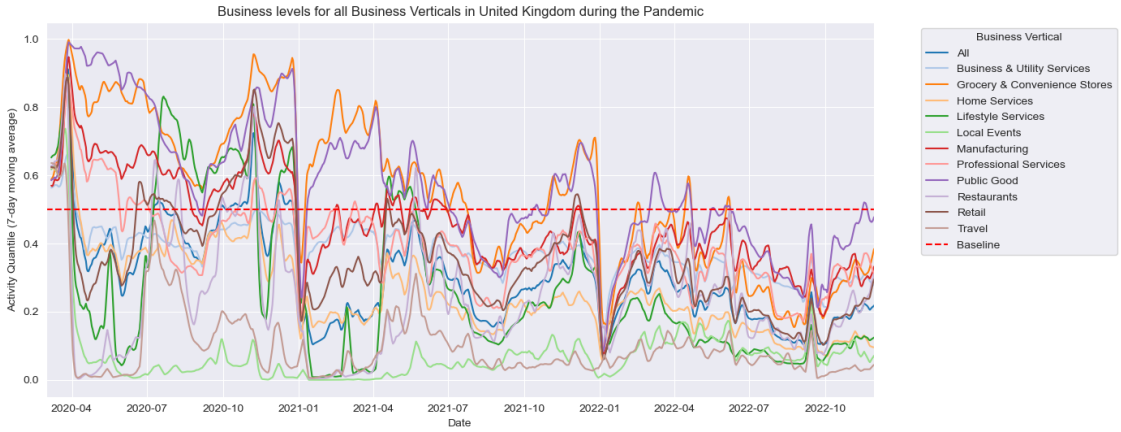

Figure 9: Change in business levels for all business verticals in the United Kingdom during the pandemic.

In the plot for Brazil (Figure 10), most business verticals, except for Local Events, have similar fluctuations which less variance between them most likely after the month of October. Local Events experienced the worst business level since the pandemic began followed by Restaurants which started of good but began dropping until it closed out with the worst performance at the end of November 2022. Grocery & Convenience Stores managed to maintain good business levels,

even though it was gradually reducing, during the pandemic. There is no major peak apart from the ones that occur regularly around May and around August. However, steep dips can be spotted at the beginning of each year.

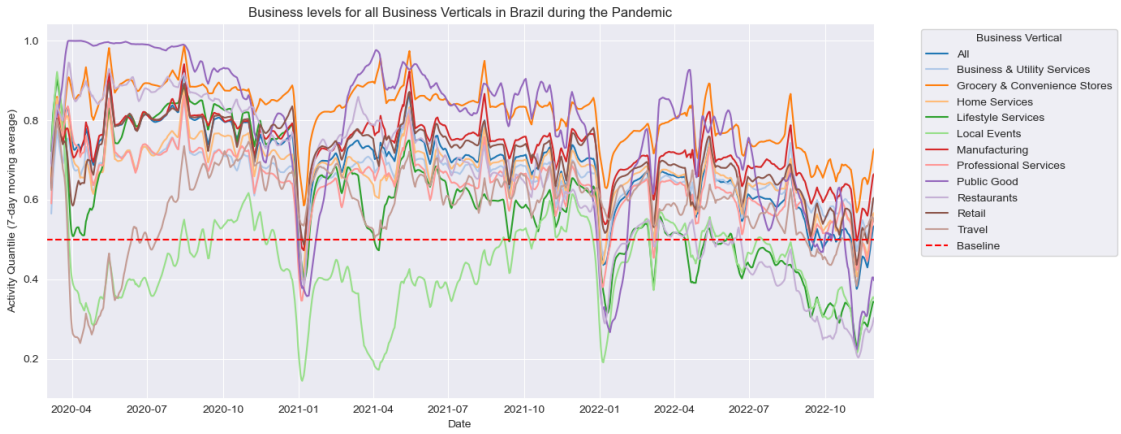

Figure 10: Change in business levels for all business verticals in the Brazil during the pandemic.

A downward trend for most business verticals in Nigeria can be seen as almost all rise to values ranging from around 0.7 to just below 1.0 around May 2020 just after experiencing a dip in April (Figure 11). From that high, business levels for almost all business verticals begin to degrade up until the end of the time period were most business verticals are below the baseline and range from around 0.1 to about 0.4. There are no relevant peaks and apart from the dip at the beginning of the pandemic, there are two others which occur somewhere around late November/early December 2020 and at early January 2021. Local events was the worst performing business vertical while Public Good was the only business vertical which managed to stay above the baseline.

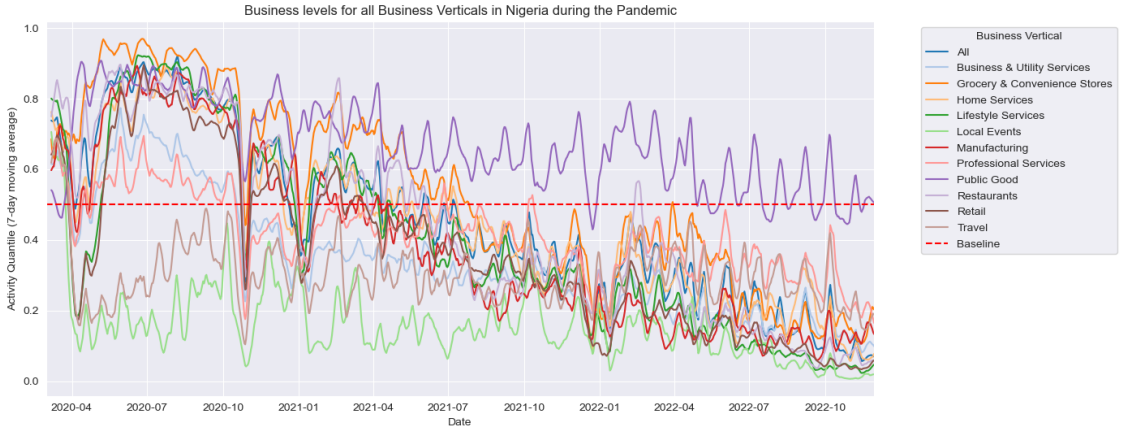

Figure 11: Change in business levels for all business verticals in the Nigeria during the pandemic.

New Zealand also shows a downward trend which is less inclined and less variable, as most of the business verticals resemble each other, than that of Nigeria (Figure 12). Here, the travel businesses suffered the most as their activity quantile stayed below 0.2 after the major dip at the beginning of the 2021. Grocery & Convenience Stores had the least poor performance out of all the other business verticals as it managed to stay just below the baseline. There are two major dips which both occur on the early weeks of January 2021 and that of 2022. However, the dip at the beginning of the pandemic in April is worth noting as a few business verticals, Travel, Restaurants, Local Events, Lifestyle services, and Retail dipped below 0.4. There aren't many high peaks apart from the one which also occurred at the beginning of the pandemic some time around May.

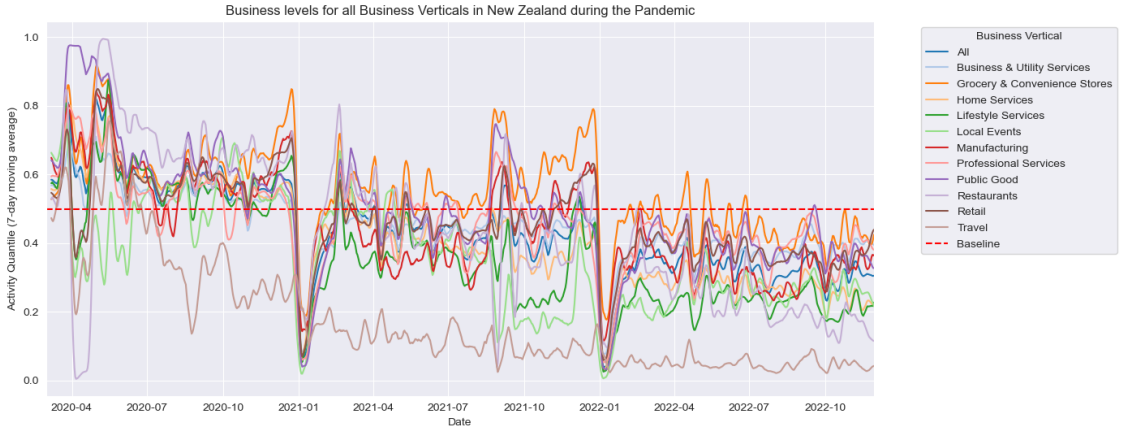

Figure 12: Change in business levels for all business verticals in the New Zealand during the pandemic.

A quick glance at the plot for Sweden (Figure 13) and we can immediately notice that, although variable, the line plot for each business vertical tend to follow each other. As such they all mostly experienced 5 dips and a seasonal pattern can be spotted. Dips occurred some time around August and at the early weeks of January throughout the time span of this data while peaks mostly occurred close to the last weeks of the year. The seasonality pattern which we also noticed in our boxplot in Figure 5 also is displayed here as the dips and peaks occurred at regular intervals. March to June and September to October mostly experienced a bit above normal activity while July-August and November to early February saw the worst business performance.

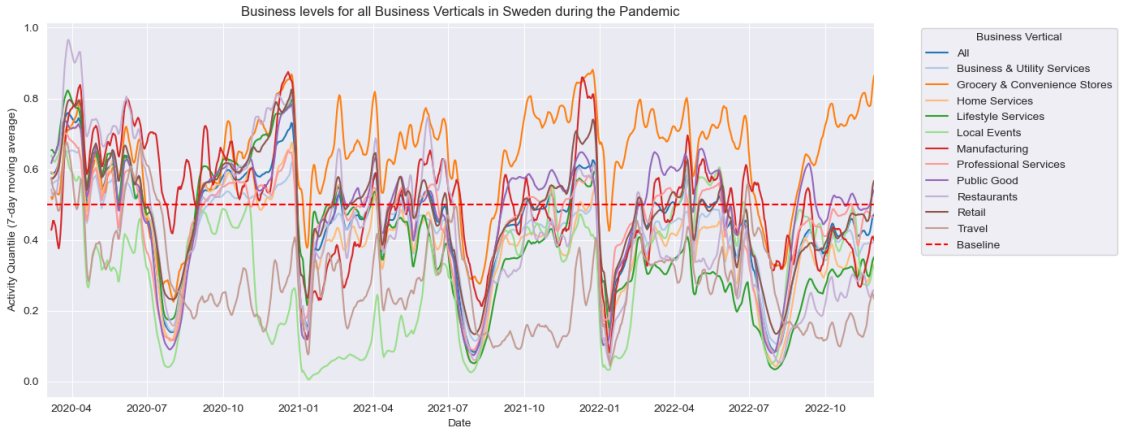

Figure 13: Change in business levels for all business verticals in the Sweden during the pandemic.

The plot for Kyrgyzstan is highly variable when looking at the business performance of all business verticals as almost all business verticals responded differently during the pandemic (Figure 14). Surprisingly, unlike other countries, the Grocery & Convenience Stores vertical was the worst performing as it dipped some time in May and ended on with an activity quantile close to 0. Also, we see that it's Manufacturing industry seems to have one of the best performances followed closely by Public Good. Despite the varying performance of the business verticals, most experienced dips around January each year. Focusing on the dip in January 2021, we can see that most business verticals had comparatively high performance in the months prior to the dip and after the dip. Paying attention to Travel business vertical we can see a drastic increase in business levels from around 0 at the start of the pandemic to some time around October 2020 before climbing up to experience the dip in January and still maintaining good business levels with a bit of variation. This is surprising as it was expected that the Travel business sector would be one of the most affected.

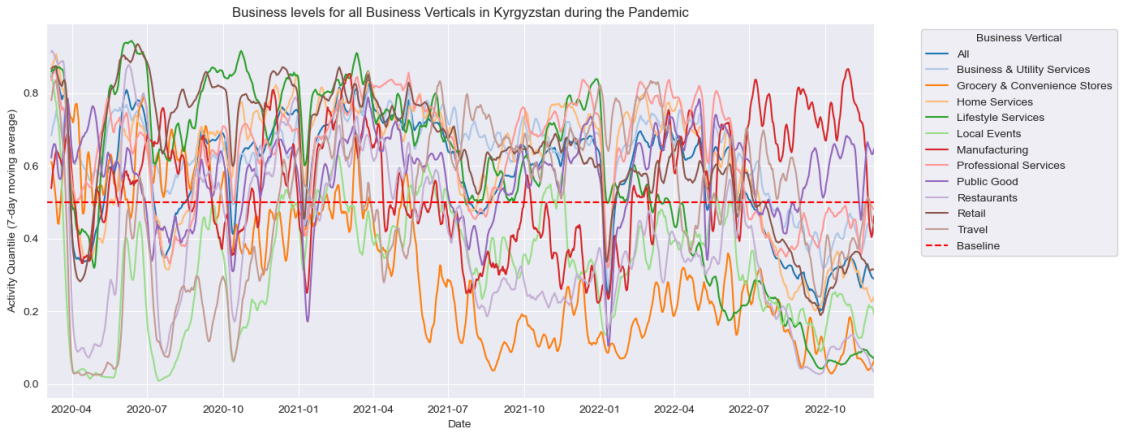

Figure 14: Change in business levels for all business verticals in the Kyrgyzstan during the pandemic.

3.2.2 Difference in activity quantile and activity percentage during analysis

When using activity percentage, as seen below as compared to Figure 23, we see how it overexaggerates the performance of businesses. This wouuld make our analysis biased if used and as a result was discarded for the activity quantile which is a better representation of business activity during the pandemic

Figure 15: This shows the bias of activity percentage as a metric for comparison

3.2.3 Understanding the changes in business levels for United Kingdom, Brazil, Nigeria, New Zealand, Sweden and Kyrgyzstan

For this portion of the analyis, only the 'All' business vertical would be looked at seeing as the authors of the dataset encoded it to capture the other 11 business verticals as well as others that aren't among it [1]. Although reference would be made to some of the plots used above, the 'All' business vertical is assumed to be representative of the business sectors for that country. Also, we made use of the Oxford COVID-19 Government Response Tracker dataset (OxCGRT) as this dataset captures the policies that were released by various governments around the world in response the COVID-19 pandemic. Amongst the other 3 categories of policies, the containment and closure policies (C) would be of use in this analysis as it captures the varying degree in which different closure policies were implement and also makes notes of important news regarding the implementation of these policies. A snippet of the basic information for the subset of the OxCGRT dataset which was used is contained in the Appendix C and Figure 16.

```
1 oxcgrt_df.info()
```
✓ 0.0s Python

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 6576 entries, 8418 to 57304
Data columns (total 19 columns):
 #   Column                                 Non-Null Count  Dtype
---  ------                                 --------------  -----
 0   CountryName                            6576 non-null   object
 1   CountryCode                            6576 non-null   object
 2   Date                                   6576 non-null   int64
 3   C1E_School closing                     6415 non-null   float64
 4   C1_Notes                               342 non-null    object
 5   C2E_Workplace closing                  5941 non-null   float64
 6   C2_Notes                               374 non-null    object
 7   C3E_Cancel public events               5952 non-null   float64
 8   C3_Notes                               347 non-null    object
 9   C4E_Restrictions on gatherings         6290 non-null   float64
 10  C4_Notes                               356 non-null    object
 11  C5E_Close public transport             6576 non-null   float64
 12  C5_Notes                               305 non-null    object
 13  C6E_Stay at home requirements          6576 non-null   float64
 14  C6_Notes                               324 non-null    object
 15  C7E_Restrictions on internal movement  6576 non-null   float64
 16  C7_Notes                               313 non-null    object
 17  C8E_International travel controls      5085 non-null   float64
 18  C8_Notes                               341 non-null    object
dtypes: float64(8), int64(1), object(10)
memory usage: 1.0+ MB
```

Figure 16: Basic information of the variables in the subset of OxCGRT that was used. Note that the data was further filtered to the range of dates that cover our FBAT dataset.

To assess the correlation of the each kind of closure and containment policies on business activity for each country, Spearman's rank correlation was used. Since Spearman's rank correlation is designed to handle ranks, there was no need to one-hot encode the ordinal data in the OxCGRT dataset [24]. From the spearman's rank correlation heatmap in Appendix D, we correlation between each policy with activity quantile for each country. In Nigeria, the policies display a strong positive correlation with activity quantile. The same can be seen in Brazil where activity quantile appears strongly positively correlated with public transport closure policies and school closure policies. However, it displaces almost no correlation with policies on restrictions on internal movement. In the heatmaps for United Kingdom, New Zealand and Sweden we see a weak correlation with the containment and closure policies while for Kyrgyzstan, almost all the policies have no correlation with activity quantile. This shows that there lies some unexplained causes for the change in levels of business activity during the COVID-19, regardless of this, we will still endeavour to draw insights using the information from policies.

Further analysis of patterns in Brazil

From Figure 17 we can see the spread of policies released along the time period of the pandemic and that a lot of policies were released between October 2020 and October 2021. With this, we'll try to understand the observations that were made about Figure 10.

Looking at the small peaks which appeared around May and August throughout the year, the following insights were found after studying that time period for Brazil.

- For 2020, policies which revolved around school closings were released and these might be important as school closure policies had a high correlation with activity quantile in Brazil. On the 25th of April 2020, schools were ordered to shut down [13]. Schools then began opening on the 5th of May even though higher education were asked to wait till the 15th [1].

- A more plausible cause for this repeated pattern is the fact that Mother's day, which is on the 12th of May, was highly celebrated in Brazil. In 2020, a pianist openly serenaded the mothers who were trapped indoors [21] and in 2021, the President at that time rode with a huge crowd of bikers through the capital city in celebration of Mother's day [29].
- Most non-essential services that were closed like restaurants, shops and bars were beginning to open up in some cities in the 10th of August [25].

For the small improvements towards end of year (Oct to Dec 2021 focus), the following insights were found;

- Although this shouldn't be the cause for a seemly seasonal effect, it appears that there was a lot of discussion on vaccines and vaccinations around that period and as a result, policies released penalized the unvaccinated more and as the majority got vaccinated, it's probable that business activity improved a bit [28][22].

Understanding the drop in New Year;

- Seeing as this occurred globally, its most likely due to the discovery of the Delta variant in late 2020 and the Omicron variant in late 2021 [15].
- This could also be due to the fact that workers take a leave for the holidays and as such business activity tends to reduce drastically.

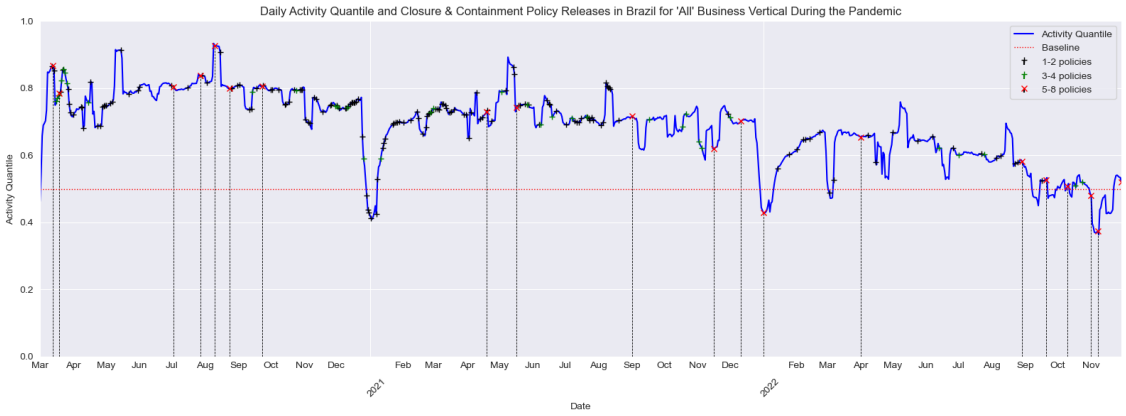

Figure 17: Daily activity quantile and closure & containment policy releases in Brazil for 'All' business vertical during the pandemic

Further analysis of patterns in United Kingdom Using Figure 9 and Figure 18 to understand the business activity in the United Kingdom, we'll try to understand the external effects that influenced the trend.

Analyzing the reasons for the sudden dip in April 2020, the following observation was found

- It appears that this was as a result of the UK government's slow response to the pandemic. Life carried on as usual since no plans were put in place to curb the devastating spread [4][23]. It was not until 23rd March 2020, which was the peak, that the prime minister at that time, announced the lockdown measures [27].

Understanding the drop in New Year;

- Seeing as this occurred globally, its most likely due to the discovery of the Delta variant in late 2020 and the Omicron variant in late 2021 [18].
- This could also be due to the fact that workers take a leave for the holidays and as such business activity tends to reduce drastically.

Understanding the unusual peak around September 2022;

- Around 18th August, we can news articles in the UK suggested that all remaining restrictions were lifted but still, this doesn't adequately explain the peak in September [2][9][11].
- The peak began on the 8th of September and lasted till the 14th of September and that start period coincides with when the late Queen Elizabeth II passed on. Probably such an event led to an increase in the number of postings for most businesses on Facebook which in turn affected the activity quantile [10].

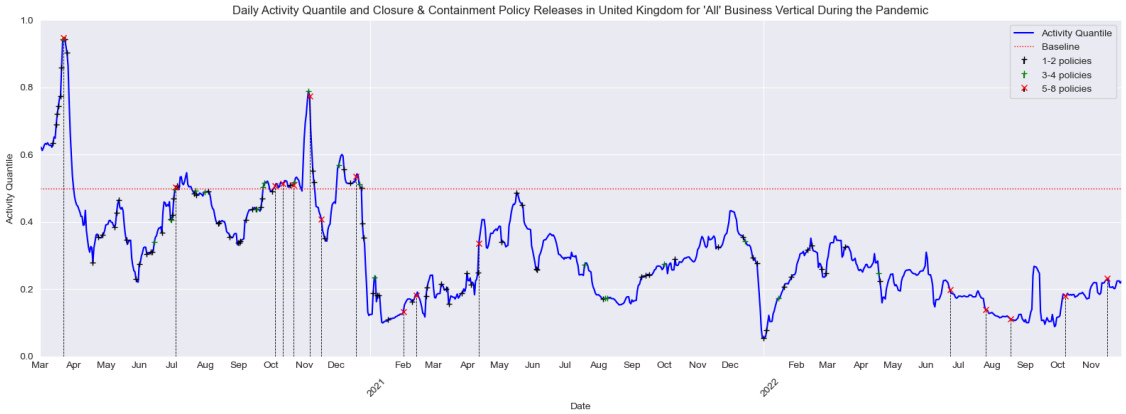

Figure 18: Daily activity quantile and closure & containment policy releases in UK for 'All' business vertical during the pandemic

Further analysis of patterns in Nigeria Using Figure 11 and Figure 19 to understand the business activity in the Nigeria, we'll try to understand the external effects that influenced the trend.

Analyzing the reasons for the sudden dip in October 2020, the following observation was found

- Dip experienced in October 2020 was most likely due to the "END-SARS" protest which was held nationwide around that time period. A lot of the citizens participated and as a result, it most likely affected business activity in that period [18][14].

Understanding the drop in New Year;

- Seeing as this occurred globally, its most likely due to the discovery of the Delta variant in late 2020 and the Omicron variant in late 2021 [18].
- This could also be due to the fact that workers take a leave for the holidays and as such business activity tends to reduce drastically.

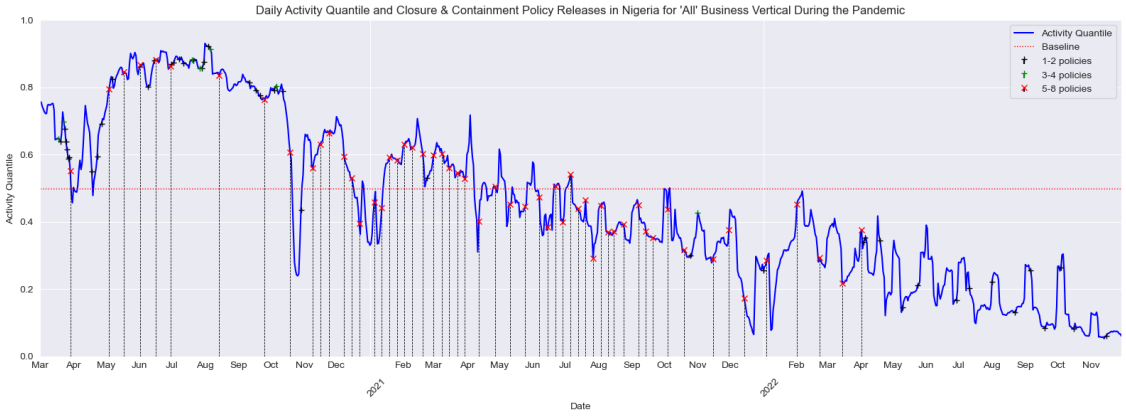

Figure 19: Daily activity quantile and closure & containment policy releases in Nigeria for 'All' business vertical during the pandemic

Further analysis of patterns in New Zealand Using Figure 12 and Figure 20 to understand the business activity in the New Zealand, we'll try to understand the external effects that influenced the trend.

Analyzing the reasons for the sudden dip in April 2020, the following observation was found

- This dip probably came as a response to all the policies that were put out but the government, which restricted movement, just a few days prior. For example looking at workplace closing policies, within a space of 1 week, i.e., from 21st March 2020 to 26th March 2020, in New Zealand [8][25][26].

Understanding the drop in New Year;

- Seeing as this occurred globally, its most likely due to the discovery of the Delta variant in late 2020 and the Omicron variant in late 2021 [18].
- This could also be due to the fact that workers take a leave for the holidays and as such business activity tends to reduce drastically.

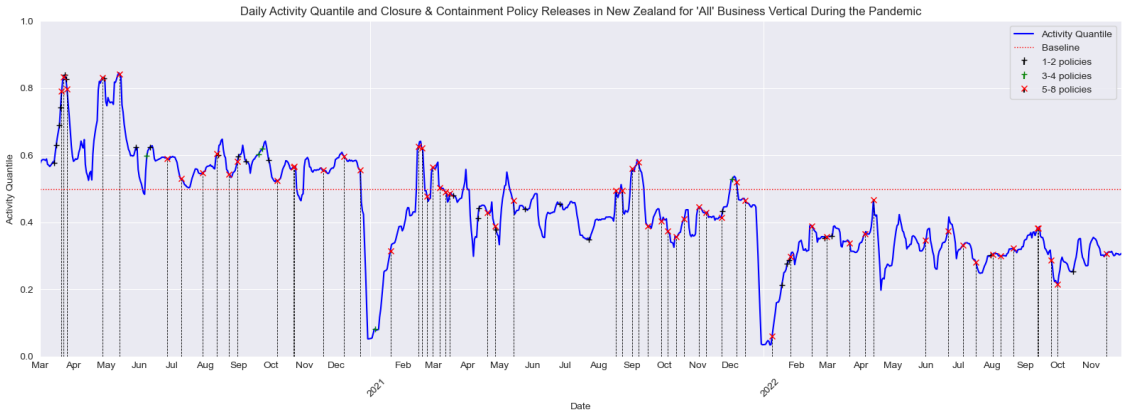

Figure 20: Daily activity quantile and closure & containment policy releases in New Zealand for 'All' business vertical during the pandemic

Further analysis of patterns in Sweden Using Figure 13 and Figure 21 to understand the business activity in the Sweden, we'll try to understand the external effects that influenced the trend.

Analyzing the reasons for the seasonal dips in late July of each year, the following observation was found

- I couldn't find an explanation as to why that seasonality occurred in Sweden. Further analysis of this is required.

Understanding the drop in New Year;

- Seeing as this occurred globally, its most likely due to the discovery of the Delta variant in late 2020 and the Omicron variant in late 2021 [18].
- This could also be due to the fact that workers take a leave for the holidays and as such business activity tends to reduce drastically.

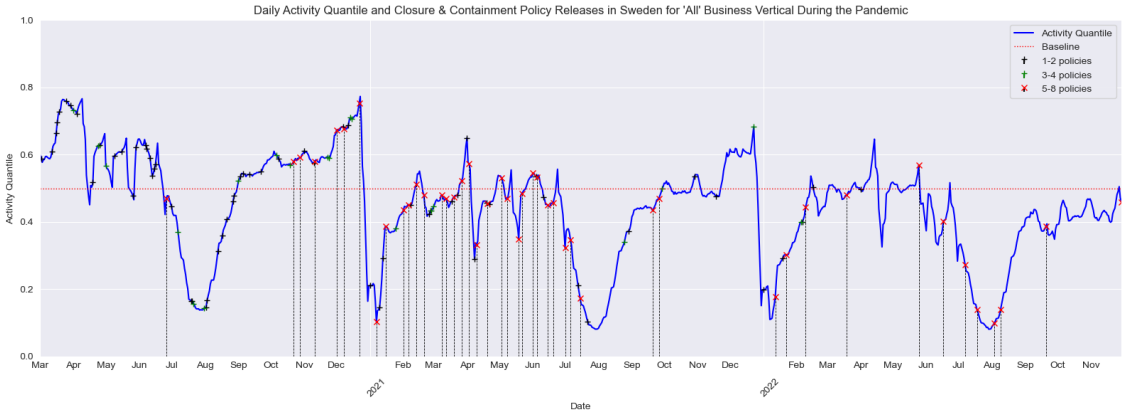

Figure 21: Daily activity quantile and closure & containment policy releases in Sweden for 'All' business vertical during the pandemic

Further analysis of patterns in Kyrgyzstan As seen in Figure 14 and Figure 22 the business levels for each industry varies from each other and except for the dips that occur at the beginning of each year, there isn't much pattern seen. Further analysis would have to be done to understand the change in business activity in Kyrgyzstan.

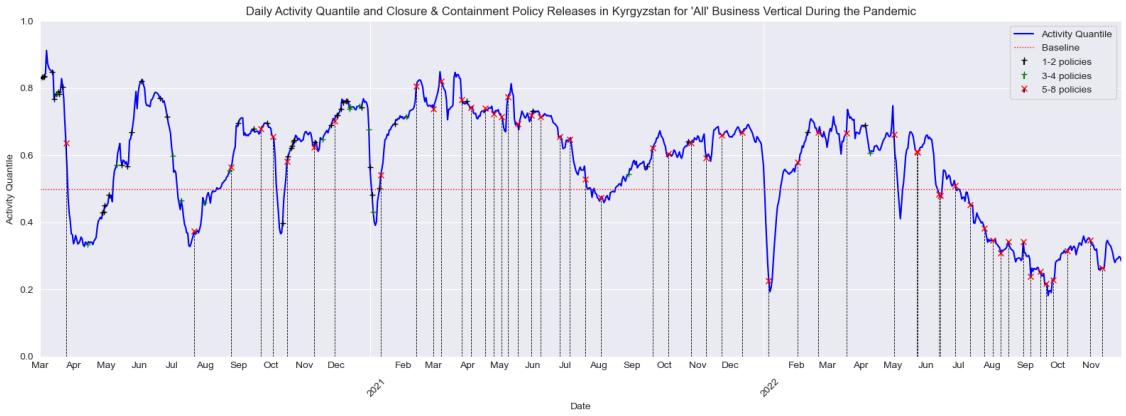

Figure 22: Daily activity quantile and closure & containment policy releases in Kyrgyzstan for 'All' business vertical during the pandemic

3.3 Reflection

3.3.1 What are the advantages and disadvantages of the two metrics

The activity percentage had a lot of outliers due to it being heavily influenced but businesses which performed extremely well, and as a result it was biased when it came to assessing the performance of a particular business sector. For the activity quantile, since it was smoothed out by taking the 7-day average for each business, it was better suited to assessing the performance of a business vertical.

3.3.2 What other kinds of data could help with this analysis?

This analysis would greatly be improved if we could also add in data which capture daily trending topics on the different social media platforms and search engines for each region. This coupled with a dataset which contained the local newspaper headlines for each day of the pandemic could aid in greatly understanding the events that surrounded some trends in the data. For example, Kyrgyzstan needed further analysis due to the fact that the dataset available just couldn't explain the variability within the different business verticals in that country.

4 Conclusion

In this research we were able to uncover the countries and business verticals which felt the brunt of the pandemic and also those which displayed remarkable resilence. Using the metric activity quantile coupled with data from Oxford COVID-19 Government Response Tracker, we were able to gain insights into the policies surrounding some trends in the country. Although business activity could be explained with more than just the policy tracker dataset, I believe that this preliminary insights would be helpful whilst deeper analysis is yet to be done.

5 Appendix A: Regression model for activity quantile against time

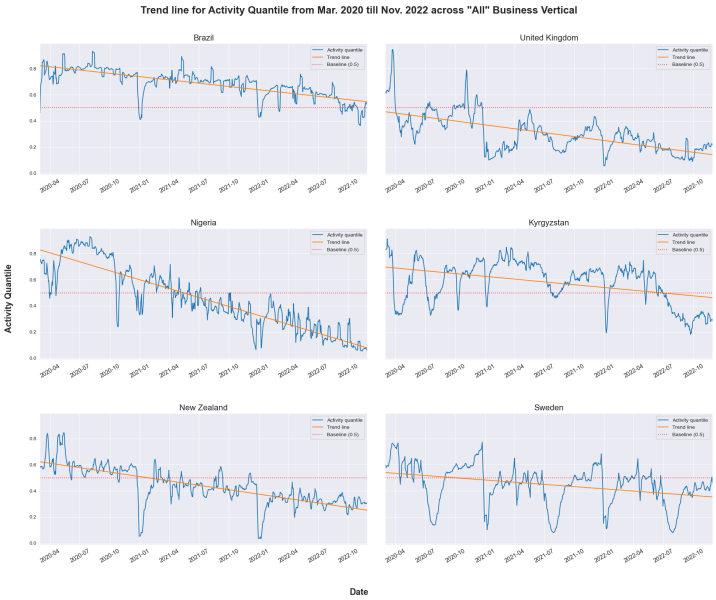

Figure 23: Regression model for activity quantile against time for all 5 chosen countries. Shows the expected long term trend of activity quantile

6 Appendix B: Daily boxplot of residuals for all 5 chosen countries for "All" business vertical

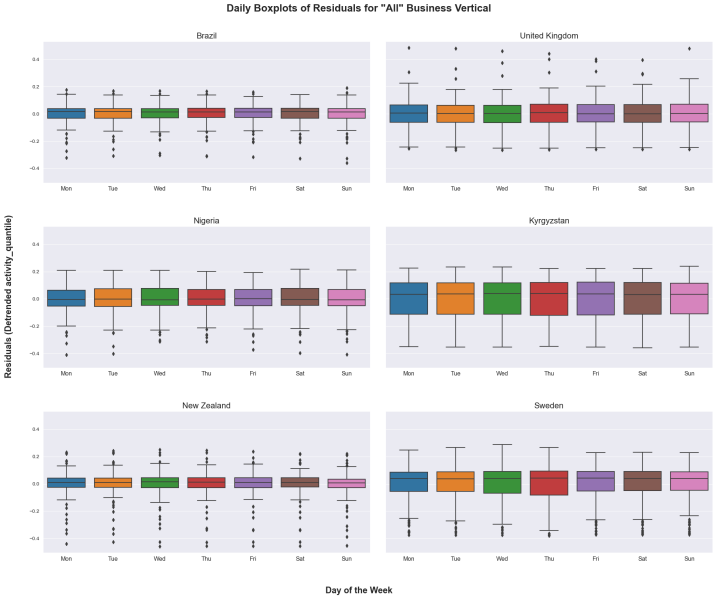

Figure 24: Daily boxplot of residuals for all 5 chosen countries for "All" business vertical. No pattern noticed due to the 7-day average smoothing that was carried out during the calculation of activity quantile.

7 Appendix C: Sorted Sample of the Oxford COVID-19 Government Response Tracker subset dataset

```
1  oxcgrt_df[oxcgrt_df.C1_Notes.notna()].sample(5).sort_index()
```

✓ 0.0s Python

Date	CountryName	CountryCode	C1E_School closing	C1_Notes	C2E_Workplace closing	C2_Notes	C3E_Cancel public events	C3_Notes	C4E_Restrictions on gatherings	C4_Notes	C5E_Close public transport
2020-10-29	Brazil	BRA	3.0	Schools remain closed in some regions, such as...	2.0	NaN	2.0	NaN	3.0	NaN	1.0
2021-01-11	Kyrgyzstan	KGZ	2.0	No changes found	2.0	NaN	0.0	No changes found. Link: https://web.archive....	4.0	No changes found. Link: https://web.archive....	0.0
2021-03-30	Nigeria	NGA	1.0	No change in policy	1.0	No change in policy	1.0	No change in policy	3.0	No change in policy	0.0
2021-09-17	Brazil	BRA	2.0	According to UNESCO, the schools are partially...	NaN	NaN	NaN	NaN	NaN	NaN	1.0
2022-05-23	Kyrgyzstan	KGZ	0.0	No changes found	0.0	Public places and services Businesses and pub...	2.0	Public gatherings are prohibited https://web....	4.0	Public gatherings are prohibited https://web....	0.0

Figure 25: Sorted sample of the subset of the Oxford COVID-19 Government Response Tracker dataset. Note: C1_notes was filtered to only show the rows that contained notes values for demonstration purposes only

8 Appendix D: Spearman's Rank Correlation Heatmap for Activity Quantile and Amount of Policies Released

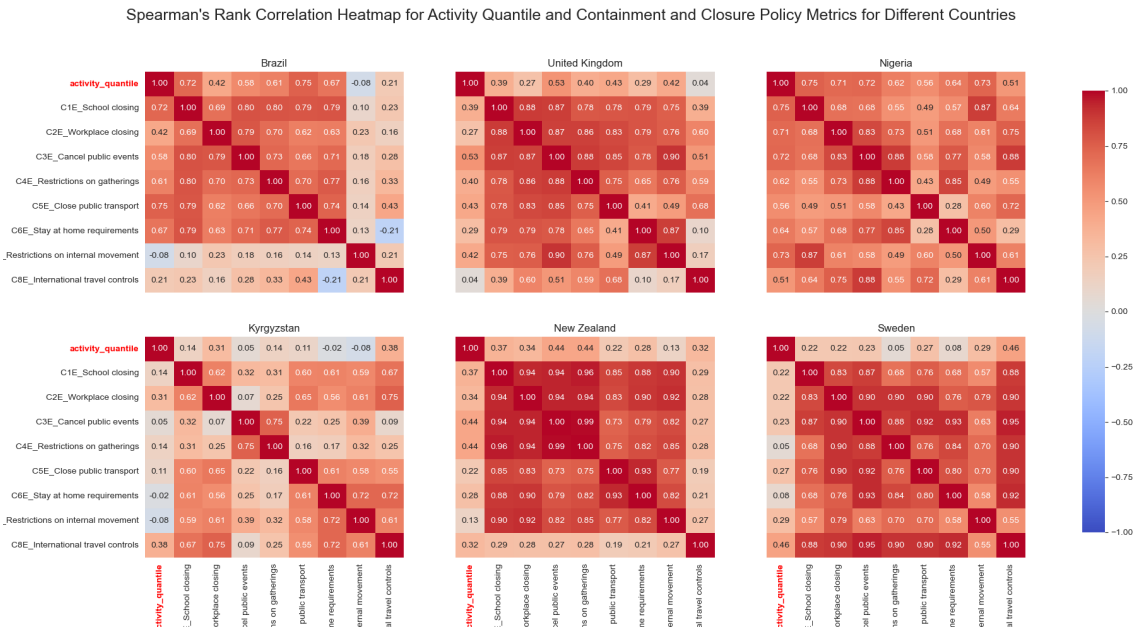

Figure 26: Spearman's Rank Correlation Heatmap for Activity Quantile for the 'All' business vertical and all Containment and Closure Policy Metrics for Different Countries

References

[1] Conversa com o ministro: otimismo com retorno de aulas e Enem 2020.

[2] Coronavirus in Scotland - gov.scot.

[3] glob — Unix style pathname pattern expansion.

[4] NRS Web Continuity Service.

[5] pandas - Python Data Analysis Library.

[6] sklearn.linear$_m$*odel.LinearRegression*.

[7] sklearn.preprocessing.StandardScaler.

[8] COVID-19 Alert System, 3 2020.

[9] Coronavirus (COVID-19): guidance and support, 7 2021.

[10] Archive | The Independent, 9 2022.

[11] Public health guidance for the general public | GOV.WALES, 7 2022.

[12] Thomas Hale, Noam Angrist, Rafael Goldszmidt, Beatriz Kira, Anna Petherick, Toby Phillips, Samuel Webster, Emily Cameron-Blake, Laura Hallas, Saptarshi Majumdar, and Helen Tatlow. A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker). *Nature Human Behaviour*, 5(4):529–538, 3 2021.

[13] https://plus.google.com/+UNESCO. COVID-19 - Situação da Educação no Brasil (por região/estado), 4 2020.

[14] Al Jazeera. Nigeria: Protesters 'shot dead' by security forces in Lagos. 10 2020.

[15] Kathy Katella. Omicron, Delta, Alpha, and More: What To Know About the Coronavirus Variants, 9 2023.

[16] Patrick Lam, Shankar Iyer, Eugenia Giraudy, and Alex Pomp. Facebook Business Activity Trends for Disaster Recovery, 11 2022.

[17] Meta. Facebook Business Activity Trends during COVID19 - Humanitarian Data Exchange.

[18] Dennis Naku. EndSARS protesters defy Wike8217;s ban, lament killings, 11 2020.

[19] OxCGRT. GitHub - OxCGRT/covid-policy-dataset: Systematic dataset of Covid-19 policy, from Oxford University.

[20] Avishek Pal and Pks Prakash. *Practical Time Series analysis*. Packt Publishing Ltd, 9 2017.

[21] Amanda Perobelli and Leonardo Benassatto. To celebrate mothers trapped in quarantine, Sao Paulo gets creative. 5 2020.

[22] Reuters. Brazil's top court orders government to set date for COVID-19 vaccination plan. 12 2020.

[23] Ian Sample and Peter Walker. Covid response 'one of UK's worst ever public health failures'. 10 2021.

[24] Patrick Schober, Christa Boer, and Lothar A. Schwarte. Correlation Coefficients: appropriate use and interpretation. *Anesthesia Analgesia*, 126(5):1763–1768, 5 2018.

[25] Spinoff. Covid-19 NZ live updates, March 23: New Zealand prepares for nationwide shutdown. 3 2020.

[26] Spinoff. Covid-19 NZ live updates, March 23: New Zealand prepares for nationwide shutdown. 3 2020.

[27] Prime Minister's Office 10 Downing Street. Prime Minister's statement on coronavirus (COVID-19): 23 March 2020. 3 2020.

[28] Rio Times. Covid-19 vaccine passport: Where is it mandatory in Brazil? - The Rio Times, 10 2021.

[29] Adry Torres. Covid Brazil: President dismisses pandemic risk by riding with dozens of bikers on Mother's Day. 5 2021.