Impact of COVID-19 on Stock Market Return and Volatility: Case Study of Canada on a Provincial, Regional, and National Level

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This paper examines the impact of COVID-19 related information measures on the S&P/TSX Composite Index return and volatility from a local market perspective. The analysis is conducted on a Canadian provincial, regional, and national level using various measures related to the COVID-19 coronavirus, such as the infectiousness of the virus, stringency of government policies, and market sentiment, to identify the main drivers of the Canadian stock market. Our empirical results show that the measures impacting stock market return and volatility differ, with return driven primarily by market sentiment, and volatility driven by the infectiousness of the virus. These results are counter to the commonly held belief of returns being driven by fundamental macroeconomic variables and volatility being driven by market sentiment. While a formal test to determine the cause of the results is not conducted, the results could have potentially been fueled by the irrational behavior of investors who were looking to cash out on riskier stock market investments or shift them to safe assets.

Keywords: COVID-19, stock returns, stock volatility, market sentiment, stringency, Canada

INTRODUCTION

No one would argue about the profound impact the COVID-19 pandemic has had on our daily lives. Within a span of less than three months since the initial identification of the highly contagious virus in late 2019, the World Health Organization (WHO) declared COVID-19 a pandemic on March 11, 2020. By the end of March 2020, global stock markets experienced massive volatility, with the S&P 500 circuit breaker triggered four times during the month of March 2020 alone.

In response to the growing fears of a COVID-19 outbreak, governments around the world have taken drastic measures, both monetary and fiscal, to contain the negative social and economic impact of the pandemic. Canada is no exception, as multiple measures were put in place to restrict, or at least slow down, the spread of the virus, and to aid businesses and households from the resulting backlash to its economy. Social distancing requirements have led to massive unemployment, business closures, and overall economic instability. Ultimately, the true effects of the government measures on the economy will likely not be known until the pandemic's dust eventually settles.

The focus of our research is to investigate the pandemic's impact on the Canadian equity market. Specifically, we seek to determine the primary drivers of stock market return and volatility for the S&P/TSX Composite index (S&P/TSX) on a provincial, regional, and national level. Canada presents a unique situation whereby the delivery of health services is primarily assigned to provinces and territories by the Constitution Act of 1867. Although the Canadian federal government assumes responsibility for national coordination and leadership, each province or territory has the responsibility of tailoring its response to meet the needs of its residents. The deregulation of authority in Canada resulted in the provinces and territories taking different approaches to deal with COVID-19, despite the efforts of the federal government. This situation is similar to the United States whereby each state has the ability to tailor its response. Subsequently, this results in difficulties of taking only a national viewpoint when analyzing the effects of COVID-19 for Canada, as it would not accurately reflect the differences in pandemic management across the provinces, territories, and regions. Furthermore, while there are no provincial-level stock market indices for Canada, the S&P/TSX would be affected by the health measures, such as business closures and pandemic-related restrictions, which are implemented at the provincial or regional levels.

We select measures that represent the infectiousness of the COVID-19 coronavirus, the stringency of government policies put in place in response to the pandemic, and the market sentiment on the coronavirus, to capture the diverse types of information that could have impacted the Canadian stock market during the pandemic. Fortunately, data at the provincial-level is available for COVID-19 infectiousness and stringency of government policies. However, data on market sentiment is only available on a national basis and is a limitation of our analysis. The sample period used is from March to December 2020, ending just prior to the implementation of the mass vaccination programs in early January 2021.

We contribute to the growing literature on COVID-19 by providing insight on the impact of various COVID-19 related information for the Canadian stock market. By conducting our analysis on a provincial, regional, and national level for Canada, we enable the identification of potential differences that may exist across the provinces and regions. The empirical results we obtain show that the measures impacting Canadian stock return and volatility differ. While the return was primarily driven by market sentiment, volatility was primarily driven by the information on the infectiousness of COVID-19. This result is counter to the commonly held belief of returns being driven by fundamental macroeconomic variables and volatility being driven by market sentiment. While a formal test to determine the cause of the results is not conducted in this study, we propose a few possible reasons, such as the speed of contagion, speed of information diffusion through various media outlets, and the growing sense of fear and panic caused by the uniqueness and widespread impact of the COVID-19 pandemic. Much like a bank run, this fear potentially fueled irrational behavior during the COVID-19 pandemic, whereby investors sought to cash out on riskier stock market investments or shift them to safer assets.

BACKGROUND INFORMATION ON COVID-19

COVID-19 is a new strain of coronavirus caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The first confirmed case of COVID-19 was reported in Wuhan, China on December 8, 2019, and within a matter of weeks it had spread to various countries globally. The first reported case of COVID-19 infection in Canada was made on January 25, 2020, with its first death from COVID-19 recorded on March 8, 2020. On March 11, 2020, the WHO officially declared the novel coronavirus outbreak to be a pandemic. By this date, Canada had more than 100 cases of COVID-19 nationwide. The rapid spread of COVID-19 in both the US and Canada led to the closure of the US-Canada border, the world's longest undefended land border, on March 18, 2020. By March 20, 2020, Canada's COVID-19 cases surpassed 1,000 and by March 22, 2020, all 13 provinces and territories have declared a state of emergency.

TABLE 1
COVID-19 INFECTION DATA SUMMARY STATISTICS FOR CANADA BY PROVINCE AND REGION

Province/Territory /Region	Prov Code	PRUID	Region	2019 Population	1st Confirmed	1st Death	*As of December 31, 2020*****					
							Confirmed	Deaths	rateconf**	Rank	ratedeath**	Rank
Newfoundland and Labrador	NL	10	Atlantic	523,476	2020-03-15	2020-03-30	390	4	74.50	11	0.76	11
Prince Edward Island	PE	11	Atlantic	157,262	2020-03-15	*NA**	94	0	59.77	12	0.00	12
Nova Scotia	NS	12	Atlantic	969,747	2020-03-16	2020-04-07	1,486	65	153.24	8	6.70	7
New Brunswick	NB	13	Atlantic	776,868	2020-03-11	2020-06-04	599	9	77.10	10	1.16	10
Quebec	QC	24	Central	8,501,703	2020-02-28	2020-03-17	202,641	8,356	***2,383.53***	***1***	***98.29***	***1***
Ontario	ON	35	Central	14,544,718	2020-01-26	2020-03-17	186,355	4,556	1,281.26	5	31.32	3
Manitoba	MB	46	Prairie	1,369,540	2020-03-13	2020-03-27	24,700	667	1,803.53	3	48.70	2
Saskatchewan	SK	47	Prairie	1,172,302	2020-03-13	2020-03-30	15,350	155	1,309.39	4	13.22	6
Alberta	AB	48	Prairie	4,361,694	2020-03-06	2020-03-20	100,428	1,046	2,302.50	2	23.98	4
British Columbia	BC	59	West	5,090,955	2020-01-28	2020-03-09	51,990	901	1,021.22	6	17.70	5
Yukon	YT	60	North	41,477	2020-03-26	2020-10-30	60	1	144.66	9	2.41	9
Northwest Territories	NT	61	North	45,028	2020-03-26	*NA*	24	0	53.30	13	0.00	12
Nunavut	NU	62	North	38,614	2020-11-06	2020-12-20	266	1	688.87	7	2.59	8
Atlantic				2,427,353	2020-03-11	2020-03-30	2,569	78	105.84	5	3.21	4
Central				23,046,421	2020-01-26	2020-03-17	388,996	12,912	1,687.88	2	***56.03***	***1***
Prairie				6,903,536	2020-03-06	2020-03-20	140,478	1,868	***2,034.87***	***1***	27.06	2
West				5,090,955	2020-01-28	2020-03-09	51,990	901	1,021.22	3	17.70	3
Northern				125,119	2020-03-26	2020-10-30	350	2	279.73	4	1.60	5
National***				**37,593,384**	**2020-01-26**	**2020-03-09**	**584,383**	**15,761**	**1,554.48**		**41.92**	

* While the first and only death for Prince Edward Island is shown to be 2020/4/8, it is deemed to be an error in the data.

** Rate Confirmed (rateconf) and Rate Deaths (ratedeath) is per 100,000 of the respective provinces population.

*** National numbers exclude those from the Diamond Princess and Grand Princes Cruise Ships, as well as Repatriated Travelers.

**** The total confirmed cases and deaths excludes the counts from the Diamond Princess and Grand Princes cruise ships, as well as repatriated travelers.

Source: Johns Hopkins CSSE database (https://github.com/CSSEGISandData/COVID-19)

Global Trends in COVID-19 Infections

The WHO reports that there were 82.43 million total confirmed COVID-19 cases and 1.80 million total COVID-19 deaths globally as of December 31, 2020. From being primarily in Wuhan, China at the end of 2019, COVID-19 infections and deaths have spread rapidly to almost every country around the world. The epicenter of the pandemic has shifted over time, starting from Asia and the Middle East in January and February to Europe in late February and March, and then to North America by mid-March/April 2020.

With a brief slowdown in the spread of the virus in mid-2020, and the relaxation of some of the more drastic social measures taken to curb the spread of the virus during the summer, many countries saw dramatic increases in the number of confirmed cases and deaths during the second half of 2020 (the "second wave"). The approval of vaccines by health authorities and the start of mass vaccination programs globally in late 2020/early 2021 brings hope that we will be able to return to more normalcy soon, albeit potentially a "new normal."

Confirmed Cases, Deaths, and Recoveries from COVID-19 in Canada

According to the data reported by the Johns Hopkin University Center for Systems Science and Engineering (JHU CSSE), there were 584,383 total confirmed cases and 15,761 total deaths in Canada as of December 31, 2020. While the total number of cases and deaths for Canada might seem small in comparison to the global numbers, this represents a rapid increase from zero confirmed cases on January 26, 2020, and zero deaths on March 9, 2020, to the numbers reported for the end of 2020. These numbers portray not only the rapid transmission of COVID-19 but also its potential toll on society if its spread is left unchecked. Table 1 provides a summary of the COVID-19 infection on a national, regional, and provincial level in Canada as of December 31, 2020.

LITERATURE REVIEW

Since the beginning of 2020, as the spread of COVID-19 infections became more global, there has been a concerted effort by many academics to research the impact of the pandemic from both a medical as well as economic point of view. With governments across the globe taking drastic social, monetary, and fiscal measures to combat the spread and impact of COVID-19 on our economies, research efforts on understanding the virus' impact on the global and local economies have increased.

One of the first published papers regarding the impact of pandemics on the stock market was by Baker et al. (2020a), which was originally available in April 2020 from the National Bureau of Economic Research (NBER). Baker et al. (2020a) compared the stock market volatility and reaction to past pandemics and found evidence suggesting that government restrictions had a significant effect on the economy. In a subsequent NBER paper, Baker et al. (2020b) assessed the economic impact of the COVID-19 pandemic using three indicators, the stock market volatility, newspaper-based economic uncertainty, and a subjective uncertainty based on business expectation surveys, to construct real-time forward-looking uncertainty measures. Using these indicators Baker et al. (2020b) quantified the increase in economic uncertainty during the early onset of the pandemic and assessed the macroeconomic impact of the pandemic. Essentially, Baker et al. (2020b) found that about half of the forecasted output contraction is attributable to the negative effect of COVID-induced uncertainty.

While there is now a vast amount of literature on COVID-19, most of the research on the financial markets has focused on identifying patterns and correlations within the local or global financial markets, particularly for the assessment of its impact on stock volatility from various angles (Albulescu, 2021; Engelhardt et al., 2020; Zhang et al, 2020). Others have conducted comparative studies of the COVID-19 pandemic's impact on either previous epidemics/pandemics or financial crises (Ru et al, 2021). Albulescu (2021) examined the effect of the WHO official new cases and deaths announcements on the realized volatility of the S&P 500, a proxy for the US financial market volatility, and found that the new cases and deaths reported globally, and in the US, amplified financial volatility. Engelhardt et al. (2020) investigated whether social trust and trust in the government affects stock market volatility during the pandemic for 47 countries. They found that stock market volatility was significantly lower in high-trust countries. Zhang et al. (2020) mapped the patterns of country specific and systemic risks for 12 global countries, as well as the potential consequence of policy interventions, and found that global financial market risk increased substantially in response to the pandemic.

Additional literature has focused on monetary and fiscal policy measures adopted during the pandemic (Ashraf, 2020; Capelle-Blancard and Desroziers, 2020; Ozili and Arun, 2020; Zaremba et al., 2020). Ashraf (2020) examined the expected economic impact of government actions on stock market returns for 77 countries during the January 22 to April 17, 2020, period and found that social distancing measures had both a direct negative effect on returns and an indirect positive effect through the reduction of confirmed cases. Other government announcements regarding public awareness, testing and quarantines, and income support resulted in positive market returns. Capelle-Blancard and Desroziers (2020) looked at how stock markets have integrated public information and policy reactions to the pandemic using a panel of 74 countries. They reported four stylized findings regarding the stock market reaction observed during the January to April 2020 sample period. Ozili and Arun (2020) empirically examined the effect of various policy measures on economic activities and stock market indices for four countries, Japan, U.K., U.S., and South Africa. They divided the policy measures into four categories and conducted regression analysis to understand the spillover effects of COVID-19 and its impact on the global economy. Zaremba et al. (2020) investigated the impact of COVID-19 on global stock market volatility, with a focus on the effect of non-pharmaceutical governmental interventions in 67 countries and found that such interventions significantly increased equity market volatility.

Increased attention regarding the role played by media coverage and sentiment in impacting stock returns have also led to several studies that have investigated this relationship during the pandemic (Arendt and Mestas, 2020; Cepoi, 2020; Haroon and Rizvi, 2020). Arendt and Mestas (2020) utilized a cross-national correlational approach to investigate whether the amount of news coverage about COVID-19, based on Lexis-Nexis international news archives, helps to predict the extent of the stock price drop for 58 countries across 5 continents. They found a positive relationship between the amount of news coverage and the extent of price drops but did not find a relationship for actual severity (number of confirmed cases and deaths) or public interest (Google search volume). However, they cautioned the interpretation of their results for determination of causal inferences given the complexity of the media effects phenomena. Cepoi (2020) investigated the stock market's reaction to COVID-19 news for the 6 most affected countries (U.S., U.K., Germany, France, Spain, and Italy), from February 3, 2020, to April 17, 2020, using a panel quantile regression model, and found that stock markets present asymmetric dependencies with COVID-19 related news information. Haroon and Rizvi (2020) analyzed the relationship between sentiment generated by COVID-19 related news and stock market volatility and found that panic-laden news was associated with increased volatility in the equity markets.

Our paper differs from the previous literature given its focus on Canada and assessment of the impact not only on a national, but also on a provincial, and regional level to determine if there are differences across provinces or regions. Provincial level analysis is conducted using multivariate regressions while the regional and national analysis is conducted using pooled panel regressions to capture the potential heterogeneity across the provinces in the region. Although a wide range of information measures are available on a country or national level, there is limited data available on a provincial level. Furthermore, some of the data used in prior studies are only available at a monthly or longer frequency for Canada. Hence, given the short time horizon of the pandemic, we selected measures that are available at a daily frequency to overcome statistical issues related to small sample sizes.

DATA AND VARIABLES USED FOR EMPIRICAL ANALYSIS

Given our objective of determining the impact and significance of the various COVID-19 information types on stock returns and volatility, we require not only appropriate measures for the various information types but also need to control for several market factors. The sample period used for our analysis includes the first and second waves of pandemic period, beginning on March 12, 2020, and ending on December 31, 2020. Although COVID-19 infection information is available for Canada starting from January 22, 2020, the availability of other variables required for our analysis pushed back the start date to March 12, 2020. Furthermore, we do not extend the sample period beyond 2020 as the nationwide rollout of mass vaccination campaigns that began in late December 2020 brought about a different dynamic to the pandemic in the period after December 2020.

The three main explanatory variables selected for our analysis are the *effective reproduction rate* (*R0*), the *Sentiment Index* (*Sentiment*), and the *Stringency Index* (*SI*), which are our proxy measures for COVID-19 disease transmissibility, market sentiment regarding the coronavirus, and strictness of government policies put in place during the pandemic, respectively. These three variables are selected based on their representativeness of the diverse types of information that the market has access to during the pandemic. The two additional market-related control variables selected are the returns on oil and gold prices. This results in a total of five independent variables (three explanatory and two control variables) used in our regression model. We utilize weekly values for all our variables (weekly returns, differences, or averages) that are calculated using the daily data due to the significant day-of-week seasonality in the data, particularly for the COVID-19 infection information. We provide details on our selected explanatory and control variables, justify their suitability for the purposes of our study, and highlight their use in prior literature, where appropriate, in the sections that follow.

Stock Market Information: S&P/TSX Composite Index

Daily price information on the S&P/TSX Composite Index for our sample period from January 2, 2020, to December 31, 2020, is obtained from Yahoo! Finance. The adjusted closing index price is used for the calculation of the weekly log return for the S&P/TSX (*TSX logRtn*).

Stock Market Volatility: Markov Switching GARCH (1,1) Conditional Volatility

The alternative dependent variable that is used in our model is a measure of stock market volatility. The difficulty in using more conventional measures of stock market volatility such as the VIX is due to the lack of a VIX equivalent measure for the Canadian stock market following the decommissioning of the Canadian version of the VIX, the S&P/TSX 60 VIX (VIXC), as of January 22, 2020, just prior to the onset of the COVID-19 pandemic in Canada.

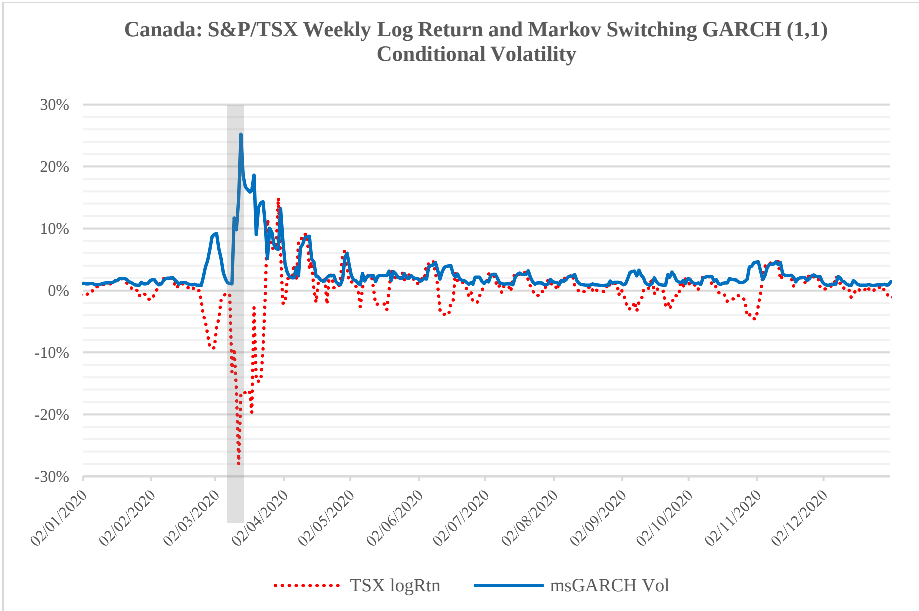
This is further exacerbated by the fact that traditional measures of volatility are difficult to use given the shorter period under investigation and the potential existence of structural breaks. Using standard measures of volatility, such as the simple rolling average volatility or the exponentially weighted moving average volatility, not only ignores the existence of a structural break but also incorporates too much long-run persistence in the volatility measure, making them inappropriate for our purposes.

Given these considerations, we chose to use the Markov switching two regime GARCH (1,1) conditional volatility (*msGARCH Vol*) as our volatility measure (Hamilton and Susmel, 1994). The Markov regime switching technique and GARCH (generalized autoregressive conditional heteroskedasticity) model has been used in prior literature for both the calculation of stock price volatility as well as identification of structural changes in volatility during the COVID-19 pandemic (Baek et al, 2020; Bora and Basistha, 2020; Just and Echaust, 2020; Onali, 2020).

Both Baek et al. (2020) and Just and Echaust (2020) found evidence of two distinct volatility regimes, a low and high regime, during the COVID-19 pandemic. Bora and Basistha (2020) utilized the Glosten-Jagannathan-Runkle (GJR) GARCH model in their analysis of the Indian stock market to better account for the volatility during the pandemic. Onali (2020) used the GARCH (1,1) model to obtain the conditional mean and variance for the stock markets of 7 countries and employed Markov switching models to identify structural breaks in the relationship between stock market returns and volatility expectations.

These studies provide support for the use of the *msGARCH Vol* as the volatility measure in our models. Figure 1 shows our estimated conditional volatility (*msGARCH Vol*) along with the weekly log return for the S&P/TSX (*TSX logRtn*) from January 2, 2020, to December 31, 2020. As shown, the estimated conditional volatility lines up well with the absolute value of the log returns for our sample period.

FIGURE 1
MARKOV SWITCHING GARCH (1,1) CONDITIONAL VOLATILITY AGAINST LOG RETURNS OF THE S&P/TSX COMPOSITE INDEX



The figure above is a graph for our calculated Markov switching GARCH (1,1) conditional volatility (*msGARCH Vol*) against the weekly log return on the S&P/TSX Composite Index (*TSX logRtn*) from January 2, 2020, to December 31, 2020. The *msGARCH Vol* was found by using a two regime Markov switching GARCH (1,1) model on the daily rolling weekly log returns for the S&P/TSX Composite Index. The grey shaded area represents the time period of the four circuit breaker triggers on March 9th, March 12th, March 16th, and March 18th, 2020, which is the period when the volatility was the highest (and returns was the lowest). Source: Yahoo! Finance.

Coronavirus (COVID-19) Information

There are many sources of information tracking COVID-19 infections. The most widely used and authoritative source of global country-by-country, as well as Canadian province-by-province information is from the Johns Hopkins University Center for Systems Science and Engineering (JHU CSSE). The JHU CSSE database provides daily data of confirmed cases and deaths for all 13 Canadian provinces, as well as the national level data, starting from January 22, 2020.

Effective Reproduction Rate (*R0*)

Based on epidemic theory, there are a wide variety of models and techniques suggested for analysis of infectious disease information. The effective reproduction rate (*R0*) measures the disease transmissibility during pandemics, which is influenced by public health responses such as social distancing and moving restrictions. It is calculated as the ratio of the new number of infections at time *t* to the total infectiousness of the infected individuals at time *t*. The infectiousness of an infected individual depends on several individual biological factors such as symptom severity.

Given that epidemiology is not an area of our expertise, we chose to rely on available data for *R0* instead of constructing our own model for the estimation of *R0*. The reason for this is due in part to the sensitivity of the calculated *R0* measure to the model inputs used, particularly with regards to the choice of serial interval used. One such available data source for *R0* is Tracking R. Tracking R's estimate of *R0* is obtained using the widely used SIR (Susceptible-Infectious-Recovered) compartmental epidemiology model with the time-varying growth rate determined using the Kalman filter from data on new cases (Arroyo-Marioli et al., 2020). We selected the 7-day serial interval estimate based on the suggestion of Cori et al. (2013).

The fact that the Tracking R estimate of *R0* is available only from March 12, 2020, onwards influenced our selection of March 12, 2020, as the start of our sample period.

RavenPack Sentiment Index

RavenPack is a leading big data analytics provider of news and sentiment analytics, which involves turning news into structured data for research purposes. In response to the COVID-19 pandemic, RavenPack launched the *Coronavirus Media Monitor* that tracks news information related to the coronavirus and provides various measures on topics conveyed in the media.

One of the measures provided is the *Sentiment Index*, which measures the level of sentiment across all entities mentioned in the news together with the coronavirus. The index ranges between -100 (most negative) and 100 (most positive) with 0 being neutral. We calculate the weekly difference in the *Sentiment Index* as a measure of the weekly change in market sentiment regarding the COVID-19 pandemic for our analysis. Unfortunately, the *Sentiment Index* is only available at the national level and not on a provincial-level and is a limitation of our analysis. Figure 2(a) shows a time-series plot of the national *Sentiment Index* (Sentiment) along with the S&P/TSX from January 2, 2020, to December 31, 2020.

Coronavirus Government Response Tracker

Data for the national and provincial government policies is obtained from the Oxford Coronavirus Government Response Tracker (OxCGRT), which provides ordinal and dollar-based measures for individual polices using 19 indicators (Hale et al., 2020). These include eight policy indicators on containment and closure policies (C1~C8), four indicators on economic policies (E1~E4), and seven indicators on health system policies (H1~H7). Additional details on the indicators are available in the Appendix and on the OxCGRT website.

These indicators are used to create four aggregated indices, namely the *Stringency Index* (*SI*, created using indicators C1~C8 and H1), the Government Response Index (*GRI*, using all of the ordinal indicators, C1~C8, E1~E2, H1~H3, and H6~H7), the Containment and Health Index (*CHI*, created using indicators C1~C8, H1~H3, and H6~H7), and the Economic Support Index (*ESI*, created using indicators E1~E2). These four indices are constructed to provide an overall impression of government responses during the COVID-19 pandemic. For the purposes of our research, we use the weekly difference in the Stringency Index (*SI*), which is a measure of the strictness of government policies taken during the pandemic.

We chose *SI* over the other indices as it utilizes only the containment and health measures relevant for our entire sample period. Compared to the *CHI*, the *SI* excludes health policies related to facial coverings (H6) and vaccinations (H7), which are policies that were not in place during the initial onset of the pandemic. As such, *SI* is believed to be a more representative measure for the purposes of our research. Figure 2(b) shows a time-series plot of the national Stringency Index (*SI*) along with the S&P/TSX from January 2, 2020, to December 31, 2020.

Market Control Variables: Oil and Gold

Daily price information on the WTI crude oil futures (CL=F) and gold futures (GC=F) was obtained from Yahoo! Finance. Oil was selected as a control variable as it faced demand and supply shocks during the pandemic and is likely a relevant and significant factor that impacted stock prices. Demand for oil fell drastically as business closures and travel restrictions were put in place. This demand shock, combined with a supply shock initiated by a price war between Russia and Saudi Arabia in March 2020, led to the price of oil futures turning negative for the first time in history in April 2020.

An additional control variable we selected was gold. Gold was found to have played a strong safe-haven asset role during the COVID-19 crisis as investors exited their risky asset positions during the pandemic (Ji et al., 2020). We use the weekly simple return on the oil and gold futures prices (*OIL* and *GOLD* respectively) as control variables in our model. We opted to use the simple and not the log returns for the control variables as the price of oil futures was negative in April 2020.

FIGURE 2
COMPARISON CHARTS OF THE S&P/TSX COMPOSITE INDEX TO THE RAVENPACK SENTIMENT INDEX AND OXCGRT STRINGENCY INDEX

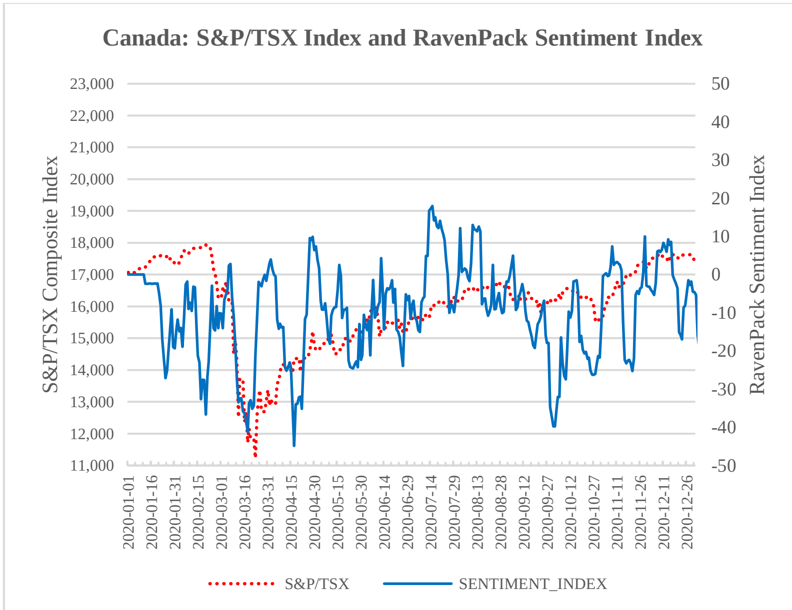


Figure 2(a): S&P/TSX Index versus RavenPack Sentiment Index

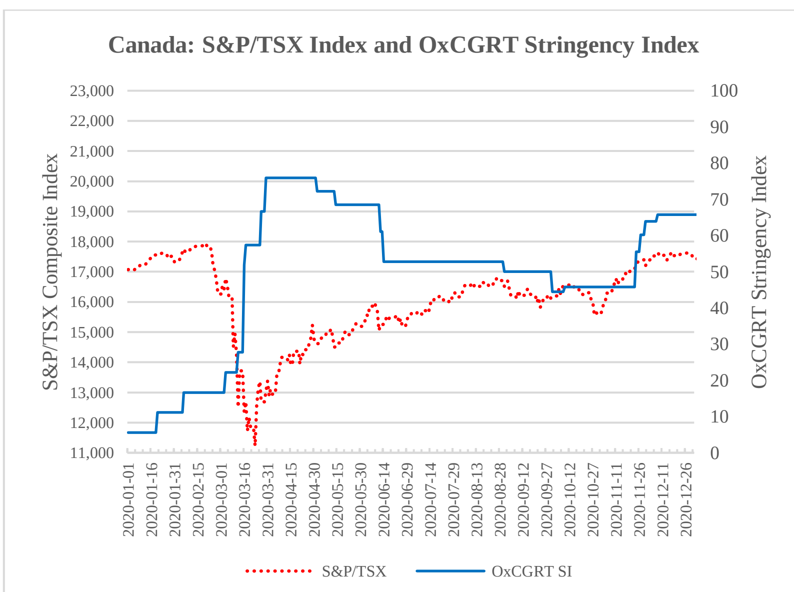


Figure 2(b): S&P/TSX Index versus OxCGRT Stringency Index

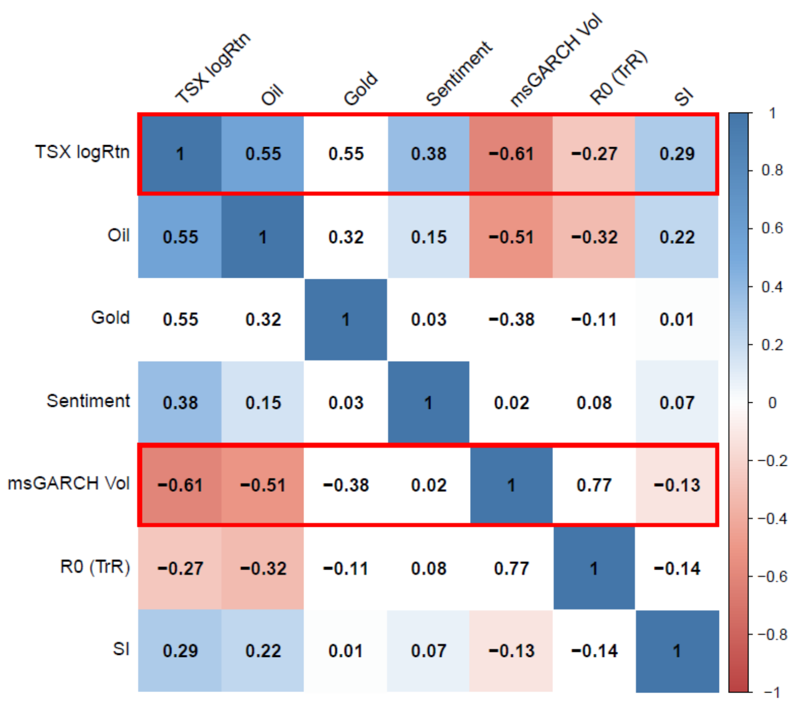
The figures above show the levels of the S&P/TSX Composite Index (dotted red line) against the RavenPack *Sentiment Index*, Figure 2(a), and against the Oxford Coronavirus Government Response Tracker's (OxCGRT) *Stringency Index*, Figure 2(b), for the period from January 1, 2020, to December 31, 2020. Source: Yahoo! Finance; RavenPack; OxCGRT

CORRELATION ANALYSIS AND EMPIRICAL MODEL

Correlation Analysis

Figure 3 shows the correlation matrix for the variables used in our regression analysis to better understand their relationship prior to the discussion of our regression results. The correlations of our two dependent variables, the weekly S&P/TSX log returns (*TSX logRtn*) and the Markov switching GARCH (1,1) conditional volatility (*msGARCH Vol*), against the explanatory and control variables for our model are highlighted using red boxes.

FIGURE 3
CORRELATION MATRIX FOR REGRESSION VARIABLES



The figure above provides the correlation between the regression variables, which includes variables related to the market, COVID-19 infection data, government measures, and the market sentiment for our sample period from March 12, 2020, to December 31, 2020. The market related variables are the weekly log return on the S&P/TSX Composite Index (*TSX logRtn*), the S&P/TSX conditional volatility based on the Markov regime switching GARCH (1,1) model (*msGARCH Vol*), the weekly return on the WTI crude oil futures price (*OIL*), and the weekly return on the gold futures price (*GOLD*). The *R0* (*TrR*), which represents the 7-day serial interval *R0* provided by Tracking R (http://www.globalrt.live/), is the effective reproduction rate found using the SIR model and applying a Kalman filter for the time-varying growth rate of new cases. *SI* is the Oxford Coronavirus Government Response Tracker (OxCGRT) Stringency Index. *Sentiment* is the RavenPack Sentiment Index. The color of the box represents the sign of the correlation, where a positive correlation is shown in blue, and a negative correlation is shown in red. The degree of significance for the correlation, using a 1% significance value, is represented by the color scheme shown on the right-hand side.

The *TSX logRtn* displays a positive correlation with both the Sentiment Index (*Sentiment*) and Stringency Index (*SI*) at 38% and 29% respectively. This indicates that stock market return reacted positively to an increase in market sentiment (more positive sentiment) or the stringency of government policies (as the pandemic is likely viewed to be better contained going forward when there are stricter policies in place). On the other hand, *TSX logRtn* displays a negative correlation with the effective reproduction rate (*R0*) at -27%. This indicates that the stock market reacted negatively when the infectiousness of COVID-19 increased. Turning to the *msGARCH Vol*, we find that stock volatility is negatively correlated to the Stringency Index (*SI*) at -13%, indicating that stock volatility decreased as the strictness of the government policies increased. Interestingly, we find no correlation between stock volatility and the Sentiment Index (*SI*). Based on behavioral economics, stock volatility tends to increase when investors are pessimistic about the market and act on their biased or emotional beliefs to sell stocks. However, based on the correlation analysis, this does not seem to be the case. Lastly, we find that stock volatility is positively but insignificantly correlated to *R0*.

Focusing on the correlation between our three explanatory variables, *Sentiment*, *SI*, and *R0*, we find that the correlations between these variables are all close to zero with weak or no significance. This not only dispels issues about potential multicollinearity between the selected explanatory variables but also suggests that they contain different information regarding the COVID-19 pandemic and are suitable for use within our regression model.

Provincial Level Analysis: Multivariate Regression Model

For our provincial level analysis, we run multivariate regressions for each of the 13 provinces and territories. The multivariate regression models used to empirically assess the impact of the various COVID-19 related measures on the stock market return and volatility are shown below:

$$TSX\ logRtn_t = \alpha_i + \beta_i Sentiment_{i,t} + \gamma_i \times SI_{i,t} + \delta_i \times R0_{i,t} + \rho_i \times OIL_t + \tau_i \times GOLD_t + \epsilon_{i,t} \quad (1)$$

$$msGARCHvol_t = \alpha_i + \beta_i \times Sentiment_{i,t} + \gamma_i \times SI_{i,t} + \delta_i \times R0_{i,t} + \rho_i \times OIL_t + \tau_i \times GOLD_t + \epsilon_{i,t} \quad (2)$$

where in Equation (1), $TSX\ logRtn_t$ refers to the weekly log return for the S&P/TSX, α_i is the intercept term for province *i*. $Sentiment_{i,t}$ is the Sentiment Index for province *i*, $SI_{i,t}$ is the Stringency Index for province *i*, and $R0_{i,t}$ is the effective reproduction rate for province *i*. OIL_t is the simple return on the WTI oil price futures, and $GOLD_t$ is the simple return on the gold price futures, our two market control variables, and $\epsilon_{i,t}$ is the error term. For Equation (2), $msGARCHvol_t$ refers to the weekly Markov switching GARCH (1,1) conditional volatility on the log returns of the S&P/TSX. All other variables in Equation (2) are the same as those for Equation (1).

National and Regional Level Analysis: Pooled Regression Model

For our national and regional analysis, we group the provinces by their respective regions and run pooled panel regressions, including the provincial effect to account for heterogeneity across provinces within the region. The pooled regression models used to empirically assess the impact of the various COVID-19 related measures on the stock market return and volatility are shown below:

$$TSX\ logRtn_t = \alpha + \beta \times Sentiment_{i,t} + \gamma \times SI_{i,t} + \delta \times R0_{i,t} + \rho \times OIL_t + \tau \times GOLD_t + \varepsilon_t \quad (3)$$

$$msGARCHvol_t = \alpha + \beta \times Sentiment_{i,t} + \gamma \times SI_{i,t} + \delta \times R0_{i,t} + \rho \times OIL_t + \tau \times GOLD_t + \varepsilon_t \quad (4)$$

The definitions of the variables used in Equations (3) and (4) are identical to those used in Equations (1) and (2). For the West Coast region, pooled regressions cannot be run since it is comprised of a single province, hence, we report our results using the multivariate regression models instead.

EMPIRICAL RESULTS

Impact of COVID-19 on Stock Returns on a Provincial Level

Table 2 shows the results of the provincial level multivariate regressions, where the dependent variable is the weekly log returns of the S&P/TSX (*TSX logRtn*) in percent. As shown in the table, the coefficients of the Sentiment Index (*Sentiment*) are positive and statistically significant at the 1% level for all 13 provinces and territories and concur with the positive relationship in our correlation analysis.

Given the unexpected and significant impact of the COVID-19 coronavirus, and the resulting social and health measures put in place to curb the spread of the virus, many companies and industries suffered significant loss of business and revenue, particularly in the airlines, hospitality, and recreation related industries. As a result, negative news about the pandemic and its impact flooded the media outlets. This caused investors to feel pessimistic about the future economic prospects of the nation and potentially led to reactionary decisions to sell their risky assets, putting downward pressure on the stock market. As the situation became more "under control" over the course of the pandemic, and due in part to the unforeseen level of monetary and fiscal stimulus the government has provided to prevent an economic downfall, market sentiment improved, which helped fuel the recovery and upward trend of the stock market. The significance of the coefficient for *Sentiment* also aligns with Cox et al. (2020), who reported that attitudes towards risk or investor sentiment that are independent of the aggregate economic state played an important causal role during the pandemic.

Looking at the other COVID-19 information measures, we find that the coefficient of the Stringency Index (*SI*) for three provinces (Manitoba, New Brunswick, and Nunavut), are positive and statistically significant level at the 5% or 10% level. The *SI* for Manitoba, New Brunswick, and Nunavut, rank 2nd, 11th, and 7th, respectively, in terms of the strictness of government policies with *SI* values of 76.85, 60.19, and 61.57, respectively, as of December 31, 2020. While the significance noticed for Manitoba could be attributed to the higher level of *SI*, the results obtained for New Brunswick and Nunavut are curious. Additional analysis on whether other factors should be included in the regression model to explain this observation might be needed. Another notable result is that the infectiousness of the COVID-19 coronavirus (*R0*) is not statistically significant for all provinces.

TABLE 2
MULTIVARIATE REGRESSIONS OF THE IMPACT OF COVID-19 MEASURES ON THE S&P/TSX COMPOSITE INDEX LOG RETURNS ON A PROVINCIAL LEVEL

	S&P/TSX Composite Index Log Returns					
	NL	**PE**	**NS**	**NB**	**ON**	**QC**
Intercept	0.158 (3.628)	1.865 (4.026)	-0.597 (2.880)	-3.494 (2.315)	2.466 (4.615)	-1.297 (3.223)
Sentiment	0.089 *** (0.025)	0.088 *** (0.026)	0.086 *** (0.024)	0.084 *** (0.024)	0.089 *** (0.026)	0.085 *** (0.025)
SI	0.036 (0.053)	0.008 (0.056)	0.051 (0.042)	0.089 ** (0.039)	-0.001 (0.067)	0.065 (0.054)
R0	-2.153 (1.734)	-2.049 (1.747)	-2.184 (1.659)	-2.201 (1.481)	-2.018 (1.734)	-2.451 (1.693)
OIL	0.049 (0.041)	0.053 (0.040)	0.046 (0.040)	0.047 (0.041)	0.053 (0.040)	0.047 (0.040)
GOLD	0.734 *** (0.176)	0.743 *** (0.178)	0.709 *** (0.170)	0.632 *** (0.153)	0.748 *** (0.176)	0.715 *** (0.175)
Adj. R^2	0.592	0.586	0.604	0.629	0.586	0.604

	S&P/TSX Composite Index Log Returns						
	MB	**SK**	**AB**	**BC**	**YT**	**NT**	**NU**
Intercept	-6.517 (4.327)	-1.849 (3.434)	0.940 (3.301)	0.579 (4.261)	1.355 (3.888)	-5.096 (7.555)	-7.197 (4.428)
Sentiment	0.087 *** (0.023)	0.087 *** (0.023)	0.089 *** (0.025)	0.089 *** (0.025)	0.088 *** (0.025)	0.086 *** (0.025)	0.082 *** (0.0217)
SI	0.128 * (0.065)	0.071 (0.057)	0.025 (0.046)	0.032 (0.070)	0.017 (0.058)	0.092 (0.097)	0.119 * (0.061)
R0	-1.702 (1.535)	-1.476 (1.586)	-2.037 (1.705)	-2.265 (1.797)	-1.935 (1.770)	-0.721 (1.893)	-0.416 (1.633)
OIL	0.049 (0.038)	0.040 (0.040)	0.051 (0.040)	0.051 (0.040)	0.052 (0.041)	0.051 (0.043)	0.030 (0.041)
GOLD	0.736 *** (0.160)	0.723 *** (0.166)	0.745 *** (0.176)	0.746 *** (0.176)	0.735 *** (0.179)	0.700 *** (0.179)	0.783 *** (0.167)
Adj. R^2	0.620	0.604	0.590	0.589	0.587	0.600	0.616

Sample period is weekly from March 12, 2020, to December 31, 2020. The dependent variable in each multivariate regression is the weekly log returns (in %) for the S&P/TSX Composite Index (*TSX logRtn*). *Sentiment* is the weekly difference in Coronavirus Sentiment Index, obtained from the RavenPack Coronavirus Media Monitor (https://coronavirus.ravenpack.com/), which ranges between -100 and 100 and measures the level of sentiment across all entities mentioned in the news alongside the coronavirus. *SI* is the weekly difference in Stringency Index, obtained from the Oxford Coronavirus Government Response Tracker (OxCGRT; https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker), which measures the strictness of various containment and health measures taken in response to the pandemic using all 9 ordinal indicators in their database (C1 to C8, and H1). *R0* is the 7-day serial interval effective reproduction rate, from the Tracking R database (http://www.globalrt.live/), estimated using the SIR model with the time-varying growth rate determined using the Kalman filter from data on new cases. *OIL* is the weekly WTI oil futures return (in %). *GOLD* is the gold futures return (in %). Heteroskedasticity and autocorrelation (HAC) robust standard errors based on Newey and West (1987) are shown in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

The results obtained indicates that the primary driver of stock returns on a provincial level is the market sentiment regarding the coronavirus, where an increase in *Sentiment* by 1-point increases *TSX logRtn* between 8.2 to 8.9 basis points across all 13 provinces and territories. This is somewhat contrary to traditional financial theory, which suggests that equity market returns are explained by fundamental rather than nonfundamental factors such as *Sentiment*.

While it is possible that *Sentiment* captures some fundamental factors that are not explicitly accounted for in our model, we do not conduct a formal test to determine this, and the cause of this relationship requires further investigation. Furthermore, the insignificance of *R0* is surprising as one would expect information on the infectiousness, and hence the severity, of the COVID-19 coronavirus to be significant. The prolonged duration of the public health measures put in place due to the pandemic might have weakened this relationship and conducting regressions for sub-periods of the pandemic might be warranted.

Impact of COVID-19 on Stock Returns on a National and Regional Level

Table 3 shows the results of the national and regional level pooled regressions, where the dependent variable is the weekly log returns of the S&P/TSX (*TSX logRtn*) in percent. Like the multivariate regression results on a provincial level shown in Table 2, the coefficients of the Sentiment Index (*Sentiment*) are positive and statistically significant at the 1% level both nationally and regionally. The major difference in the results obtained, in comparison to the provincial level results, is the positive and statistically significant coefficient obtained for the Stringency Index (*SI*) for the Prairie Provinces. The Prairie Provinces accounts for 24.3% of Canada's GDP, 18.4% of the Canadian population, and 24.3% of the S&P/TSX market capitalization as of December 31, 2019. Given that Manitoba is part of the Prairie Provinces, and we have found the *SI* coefficient to be statistically significant in our provincial level regression for Manitoba, it is not surprising that the *SI* coefficient for the Prairie Provinces is also statistically significant in the regional level regression. Furthermore, for the stringency in government policies, the Prairie Provinces rank second among the five regions, with an average *SI* of 66.4 as of the end of December 2020, which is lower only in comparison to Central Canada, with an average SI of 75.5.

TABLE 3
POOLED REGRESSIONS OF THE IMPACT OF COVID-19 MEASURES ON THE S&P/TSX COMPOSITE INDEX LOG RETURNS ON A NATIONAL AND REGIONAL LEVEL

	S&P/TSX Composite Index Log Returns					
	National	**Atlantic Provinces**	**Central Canada**	**Prairie Provinces**	**West Coast†**	**Northern Territories**
Intercept	0.307	-0.347	0.174	0.299	0.579	-0.337
	(2.413)	(2.551)	(2.538)	(1.615)	(4.633)	(2.285)
Sentiment	0.088 ***	0.087 ***	0.087 ***	0.088 ***	0.089 ***	0.087 ***
	(0.023)	(0.021)	(0.018)	(0.020)	(0.028)	(0.020)
SI	0.033	0.044	0.038	0.034 ***	0.032	0.037
	(0.028)	(0.034)	(0.039)	(0.013)	(0.077)	(0.025)
R0	-1.986	-2.155	-2.181 *	-1.914	-2.265	-1.621
	(1.713)	(1.538)	(1.288)	(1.442)	(1.914)	(1.458)
OIL	0.050	0.049	0.051 *	0.050	0.051	0.050
	(0.040)	(0.036)	(0.029)	(0.033)	(0.046)	(0.034)
GOLD	0.735 ***	0.716 ***	0.734 ***	0.741 ***	0.746 ***	0.736 ***
	(0.162)	(0.146)	(0.121)	(0.136)	(0.196)	(0.138)
Adj. R^2	0.639	0.636	0.618	0.628	0.589	0.626

† For the West Coast Region, the results shown above are for a multivariate regression given that the region only has one province, namely British Columbia.
Sample period is weekly from March 12, 2020, to December 31, 2020. The dependent variable in each pooled regression is the weekly log returns (in %) for the S&P/TSX Composite Index (*TSX logRtn*). *Sentiment* is the weekly difference in Coronavirus Sentiment Index, obtained from the RavenPack Coronavirus Media Monitor (https://coronavirus.ravenpack.com/), which ranges between -100 and 100 and measures the level of sentiment across all entities mentioned in the news alongside the coronavirus. *SI* is the Stringency Index, obtained from the Oxford Coronavirus Government Response Tracker (OxCGRT; https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker), measures the strictness of various containment and health measures taken in response to the pandemic using all 9 ordinal indicators in their database (C1 to C8, and H1). *R0* is the 7-day serial interval effective reproduction rate, from the Tracking R database (http://www.globalrt.live/), estimated using the SIR model with the time-varying growth rate determined using the Kalman filter from data on new cases. *OIL* is the weekly WTI oil futures return (in %). *GOLD* is the weekly gold futures return (in %). Robust clustered standard errors are shown in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

In addition, the infectiousness of the COVID-19 coronavirus (*R0*) is not statistically significant for all regions except for Central Canada, albeit only at the 10% level. The significance of *R0* for Central Canada is somewhat expected, given that the region ranks second in terms of the rate of confirmed cases, with more than 1,687 confirmed cases per 100,000 population, and highest in terms of the rate of deaths with more than 56 deaths per 100,000 population as of December 31, 2020 (refer to Table 1). The lack of significance of the *R0* coefficients for the other regions is somewhat curious but might be explained using downward social comparison theory. A downward social comparison takes place when we compare ourselves to others who are worse off than us to make ourselves feel that we are better off than them. Hence, given that the other regions have vastly smaller cumulative number of confirmed cases and deaths compared to Central Canada, this could have conveyed a false sense of security in the other regions. The next highest number of cumulative confirmed cases and deaths is in the Prairie Provinces, but even then, it is only about 36% and 14%, respectively, of the numbers reported by Central Canada. In an even more drastic comparison, the Atlantic Provinces and Northern Territories have reported less than 1% of the numbers reported by Central Canada.

Overall, the results of the regional pooled regressions by regions agree with the results obtained for the provincial multivariate regressions, whereby the primary driver of stock returns is the market sentiment regarding the coronavirus. An increase in *Sentiment* by 1-point increases *TSX logRtn* by almost 9 basis points. We forego a detailed discussion of these results as it is discussed in our provincial level analysis.

Impact of COVID-19 on Stock Volatility on a Provincial Level

Table 4 shows the results of the provincial level multivariate regressions, where the dependent variable is the Markov switching GARCH (1,1) conditional volatility of log returns for the S&P/TSX (*msGARCHvol*) in percent. As shown, the coefficients for the infectiousness of the COVID-19 coronavirus (*R0*) are positive and statistically significant for at the 1% level for all 13 provinces and territories.

TABLE 4
MULTIVARIATE REGRESSIONS OF THE IMPACT OF COVID-19 MEASURES ON THE S&P/TSX COMPOSITE INDEX MARKOV SWITCHING GARCH (1,1) CONDITIONAL VOLATILITY ON A PROVINCIAL LEVEL

	S&P/TSX Composite Index Markov Switching GARCH (1,1) Conditional Volatility					
	NL	**PE**	**NS**	**NB**	**ON**	**QC**
Intercept	-8.554 ***	-9.193 ***	-6.308 ***	-6.353 ***	-8.090 ***	-6.915 ***
	(1.308)	(1.355)	(1.226)	(1.006)	(2.422)	(1.247)
Sentiment	0.007	0.003	0.004	0.004	0.0039	0.003
	(0.010)	(0.010)	(0.011)	(0.013)	(0.012)	(0.011)
SI	0.085 ***	0.093 ***	0.052 ***	0.046 **	0.078 *	0.064 ***
	(0.018)	(0.019)	(0.013)	(0.019)	(0.040)	(0.018)
R0	4.777 ***	4.773 ***	4.926 ***	4.996 ***	4.939 ***	4.668 ***
	(0.766)	(0.657)	(0.842)	(0.929)	(0.745)	(0.921)
OIL	-0.033 **	-0.029 **	-0.031 **	-0.027 **	-0.024 **	-0.029 **
	(0.014)	(0.013)	(0.012)	(0.012)	(0.011)	(0.013)
GOLD	-0.276 ***	-0.287 ***	-0.284 ***	-0.305 ***	-0.262 ***	-0.277 ***
	(0.079)	(0.078)	(0.086)	(0.088)	(0.081)	(0.084)
Adj. R^2	0.785	0.802	0.739	0.720	0.737	0.736

	S&P/TSX Composite Index Markov Switching GARCH (1,1) Conditional Volatility						
	MB	**SK**	**AB**	**BC**	**YT**	**NT**	**NU**
Intercept	-3.681	-7.335 ***	-6.737 ***	-8.842 ***	-9.471 ***	-10.790 ***	-8.721 ***
	(2.673)	(1.472)	(1.301)	(1.362)	(1.474)	(2.409)	(3.143)
Sentiment	0.007	0.006	0.008	0.008	0.005	0.004	0.003
	(0.014)	(0.011)	(0.011)	(0.010)	(0.011)	(0.012)	(0.011)
SI	0.006	0.068 ***	0.060 ***	0.099 ***	0.102 ***	0.093 ***	0.067 *
	(0.036)	(0.018)	(0.016)	(0.021)	(0.020)	(0.029)	(0.039)
R0	5.104 ***	5.609 ***	5.051 ***	4.340 ***	5.601 ***	6.391 ***	5.998 ***
	(0.824)	(0.858)	(0.809)	(0.787)	(0.710)	(0.874)	(0.920)
OIL	-0.023 *	-0.036 ***	-0.028 **	-0.032 **	-0.030 **	-0.025 *	-0.037 ***
	(0.012)	(0.011)	(0.012)	(0.015)	(0.012)	(0.013)	(0.011)
GOLD	-0.245 ***	-0.268 ***	-0.251 ***	-0.248 ***	-0.315 ***	-0.292 ***	-0.225 **
	(0.090)	(0.088)	(0.078)	(0.077)	(0.081)	(0.090)	(0.095)
Adj. R^2	0.689	0.733	0.753	0.777	0.805	0.726	0.715

Sample period is weekly from March 12, 2020, to December 31, 2020. The dependent variable in each multivariate regression is the Markov Switching GARCH (1,1) Conditional volatility of weekly log returns (in %) for the S&P/TSX Composite Index (*msGARCHvol*). *Sentiment* is the weekly difference in Coronavirus Sentiment Index, obtained from the RavenPack Coronavirus Media Monitor (https://coronavirus.ravenpack.com/), which ranges between -100 and 100 and measures the level of sentiment across all entities mentioned in the news alongside the coronavirus. *SI* is the weekly difference in Stringency Index, obtained from the Oxford Coronavirus Government Response Tracker (OxCGRT; https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker), which measures the strictness of various containment and health measures taken in response to the pandemic using all 9 ordinal indicators in their database (C1 to C8, and H1). *R0* is the 7-day serial interval effective reproduction rate, from the Tracking R database (http://www.globalrt.live/), estimated using the SIR model with the time-varying growth rate determined using the Kalman filter from data on new cases. *OIL* is the weekly WTI oil futures return (in %). *GOLD* is the gold futures return (in %). Heteroskedasticity and autocorrelation (HAC) robust standard errors based on Newey and West (1987) are shown in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

The results obtained for the coefficients of *R0* could potentially be driven by the unexpected and widespread impact the COVID-19 coronavirus has had on our economy and lives. The pandemic not only significantly disrupted global supply and demand but there was a propagation of fear about the pandemic's impact on our economy as businesses and schools were closed in March 2020. All of this could have contributed to a dramatic increase in stock volatility during this period. Across all 13 provinces, an increase in *R0* by 1 point increases stock market volatility on average by about 5.2%, ranging between 4.3% to 6.4% depending on the province.

The positive and statistically significant coefficients obtained for *SI* are somewhat unexpected, unless we assume that investors view stricter government policies as a negative. One would have expected the opposite, as stricter government policies, particularly related to containment such as social distancing and movement restrictions, would likely lead to lower stock volatility given the expectation that the pandemic would be better contained and controlled with such measures in place. It is also surprising that this aspect is not captured by *Sentiment*, our measure for the market's sentiment regarding the coronavirus, as the coefficients for *Sentiment* in our regression model are found to be statistically insignificant for all provinces and territories.

One potential explanation for the results obtained for the *SI* variable is that investors view increasing stringency as being detrimental to businesses and, hence, project lower expected returns going forward. A possible explanation regarding the results obtained for the Sentiment Index could be the way in which this index is constructed. The Sentiment Index looks at news events that co-mention the coronavirus rather than a count of the number of news articles mentioning the coronavirus. Future extensions of this research will look at other coronavirus indices provided by RavenPack, such as the Panic, Media Hype, or Media Coverage Indices (which are indices constructed based on news counts rather than events). Our suspicions regarding the Sentiment Index would be verified if the alternative media related coronavirus sentiment indices are found to be significant.

Impact of COVID-19 on Stock Volatility on a National and Regional Level

Table 5 shows the results of the provincial level multivariate regressions, where the dependent variable is the Markov switching GARCH (1,1) conditional volatility of log returns for the S&P/TSX (*msGARCHvol*) in percent.

TABLE 5
POOLED REGRESSIONS OF THE IMPACT OF COVID-19 MEASURES ON THE S&P/TSX COMPOSITE INDEX MARKOV SWITCHING GARCH (1,1) CONDITIONAL VOLATILITY ON A NATIONAL AND REGIONAL LEVEL

	S&P/TSX Composite Index Markov Switching GARCH (1,1) Conditional Volatility					
	National	Atlantic Provinces	Central Canada	Prairie Provinces	West Coast†	Northern Territories
Intercept	-6.246 ***	-7.128 ***	-7.288 ***	-5.287 ***	-8.842 ***	-7.452 ***
	(1.030)	(1.178)	(0.995)	(0.958)	(1.468)	(0.834)
Sentiment	0.006	0.005	0.003	0.007	0.008	0.005
	(0.011)	(0.009)	(0.008)	(0.010)	(0.011)	(0.009)
SI	0.046 ***	0.061 ***	0.068 ***	0.032 **	0.099 ***	0.056 ***
	(0.013)	(0.017)	(0.015)	(0.013)	(0.022)	(0.008)
R0	5.138 ***	4.901 ***	4.801 ***	5.192 ***	4.340 ***	5.699 ***
	(0.816)	(0.756)	(0.608)	(0.696)	(0.839)	(0.689)
OIL	-0.027 **	-0.029 ***	-0.0268 ***	-0.026 ***	-0.032 *	-0.029 ***
	(0.011)	(0.011)	(0.009)	(0.010)	(0.016)	(0.010)
GOLD	-0.251 ***	-0.273 ***	-0.249 ***	-0.245 ***	-0.220 ***	-0.261 ***
	(0.076)	(0.067)	(0.053)	(0.066)	(0.083)	(0.067)
Adj. R^2	0.756	0.774	0.752	0.733	0.777	0.748

† For the West Coast Region, the results shown above are for a multivariate regression given that the region only has one province, namely British Columbia.

Sample period is weekly from March 12, 2020, to December 31, 2020. The dependent variable in each pooled regression is the Markov Switching GARCH (1,1) Conditional volatility of weekly log returns (in %) for the S&P/TSX Composite Index (*msGARCHvol*). *Sentiment* is the weekly difference in Coronavirus Sentiment Index, obtained from the RavenPack Coronavirus Media Monitor (https://coronavirus.ravenpack.com/), which ranges between -100 and 100 and measures the level of sentiment across all entities mentioned in the news alongside the coronavirus. *SI* is the Stringency Index, obtained from the Oxford Coronavirus Government Response Tracker (OxCGRT; https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker), measures the strictness of various containment and health measures taken in response to the pandemic using all 9 ordinal indicators in their database (C1 to C8, and H1). *R0* is the 7-day serial interval effective reproduction rate, from the Tracking R database (http://www.globalrt.live/), estimated using the SIR model with the time-varying growth rate determined using the Kalman filter from data on new cases. *OIL* is the weekly WTI oil futures return (in %). *GOLD* is the weekly gold futures return (in %). Robust clustered standard errors are shown in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Similar to the results obtained for the provincial multivariate regressions, the coefficients for the Stringency Index (*SI*) and the infectiousness of the COVID-19 coronavirus (*R0*) are positive and statistically significant at the 1% level both nationally and regionally. Likewise, we observe that the coefficients for *SI* are statistically significant for most of the regions but the coefficients for *Sentiment* are statistically insignificant both nationally and for all five regions.

Overall, the results of the regional pooled regressions by regions agree with the results obtained for the provincial multivariate regressions, whereby the primary driver of stock volatility is the information regarding the infectiousness of COVID-19. An increase in *R0* by 1 point increases stock volatility on average by about 5.0%, ranging between 4.3% to 5.7% depending on the region. We forego a detailed discussion of these results as it is discussed in our provincial level analysis.

ROBUSTNESS CHECK: ALTERNATIVE MEASURE OF STOCK VOLATILITY

To ensure the robustness of our results using *msGARCHvol*, we utilize a high frequency realized volatility as an alternative volatility measure in our model. Given the real-time impact and information transmission of the COVID-19 pandemic, the use of high-frequency data for calculation of the stock index volatility is appropriate for analyzing the COVID-19 pandemic.

High-Frequency Realized Volatility: Oxford-Man Institute of Quantitative Finance

Drawing high frequency data from the Thomson Reuters DataScope Tick History database, the University of Oxford, Oxford-Man Institute (OMI) of Quantitative Finance provides downloadable realized volatility estimations of various global stock index, including the S&P/TSX, for both 5-minute and 10-minute intervals. We utilize the realized volatility data provided by the OMI database to construct an alternative measure of stock market volatility for use in our models.

Revised Regression Models for Robustness Check

The multivariate and pooled regression models used for the robustness check using the OMI realized volatility measure are essentially the same as Equations (2) and (4). We simply replace the *msGARCHvol* dependent variable with the Oxford-Man Institute's (OMI) high frequency 5-minute realized volatility in percent (*TSX_rvol5*) and rerun the provincial and regional/national regressions. The revised regression equations used for our robustness check using the OMI realized volatility measure are shown below.

$$TSX\_rvol5_t = \alpha_i + \beta_i \times Sentiment_{i,t} + \gamma_i \times SI_{i,t} + \delta_i \times R0_{i,t} + \rho_i \times OIL_t + \tau_i \times GOLD_t + \epsilon_{i,t} \quad (5)$$

$$TSX\_rvol5_t = \alpha + \beta \times Sentiment_{i,t} + \gamma \times SI_{i,t} + \delta \times R0_{i,t} + \rho \times OIL_t + \tau \times GOLD_t + \varepsilon_t \quad (6)$$

Results Using High-Frequency Realized Volatility

Tables 6 and 7 present our results for the provincial level multivariate and national/regional pooled panel regressions, respectively, where the dependent variable is the high-frequency realized volatility for the S&P/TSX (*TSX_rvol5*) in percent. The results obtained using *TSX_rvol5* are in line with the results obtained when the Markov switching GARCH (1,1) conditional volatility of log returns for the S&P/TSX (*msGARCHvol*) is used. This provides assurance of our results in Tables 4 and 5.

TABLE 6
MULTIVARIATE REGRESSIONS OF THE IMPACT OF COVID-19 MEASURES ON THE S&P/TSX COMPOSITE INDEX HIGH FREQUENCY 5-MINUTE REALIZED VOLATILITY ON A PROVINCIAL LEVEL

	S&P/TSX Composite Index High Frequency 5-minute Realized Volatility					
	NL	**PE**	**NS**	**NB**	**ON**	**QC**
Intercept	-39.841 ***	-44.162 ***	-29.991 ***	-32.900 ***	-38.296 ***	-28.516 ***
	(8.086)	(7.578)	(7.301)	(7.189)	(11.686)	(7.299)
Sentiment	0.025	0.006	0.010	0.010	0.005	0.011
	(0.041)	(0.039)	(0.040)	(0.038)	(0.039)	(0.041)
SI	0.394 ***	0.454 ***	0.250 ***	0.264 **	0.375 *	0.231 **
	(0.121)	(0.112)	(0.087)	(0.115)	(0.194)	(0.104)
R0	23.518 ***	23.429 ***	24.178 ***	24.438 ***	24.254 ***	23.445 ***
	(4.501)	(3.842)	(4.811)	(5.322)	(4.498)	(5.294)
OIL	-0.013	0.002	-0.006	0.011	0.027	0.009
	(0.059)	(0.051)	(0.053)	(0.052)	(0.042)	(0.047)
GOLD	-0.012	-0.074	-0.054	-0.209	0.051	0.018
	(0.255)	(0.221)	(0.272)	(0.310)	(0.244)	(0.284)
Adj. R^2	0.747	0.783	0.693	0.684	0.688	0.660

	S&P/TSX Composite Index High Frequency 5-minute Realized Volatility						
	MB	**SK**	**AB**	**BC**	**YT**	**NT**	**NU**
Intercept	-6.760	-34.794 ***	-28.163 ***	-35.844 ***	-45.592 ***	-48.451 ***	-30.086 *
	(13.104)	(8.733)	(7.398)	(8.451)	(8.275)	(14.822)	(17.206)
Sentiment	0.026	0.017	0.028	0.026	0.014	0.011	0.014
	(0.040)	(0.041)	(0.041)	(0.041)	(0.038)	(0.039)	(0.045)
SI	-0.125	0.325 **	0.222 **	0.365 ***	0.497 ***	0.408 **	0.182
	(0.165)	(0.121)	(0.093)	(0.126)	(0.121)	(0.182)	(0.211)
R0	24.664 ***	27.461 ***	24.827 ***	22.211 ***	27.470 ***	30.709 ***	27.428 ***
	(4.772)	(4.852)	(4.880)	(4.780)	(3.996)	(5.145)	(5.374)
OIL	0.035	-0.029	0.012	0.001	-0.001	0.023	-0.005
	(0.053)	(0.054)	(0.049)	(0.049)	(0.048)	(0.045)	(0.057)
GOLD	0.144	0.022	0.111	0.123	-0.211	-0.073	0.188
	(0.271)	(0.268)	(0.266)	(0.260)	(0.256)	(0.290)	(0.261)
Adj. R^2	0.629	0.684	0.676	0.694	0.788	0.666	0.635

Sample period is weekly from March 12, 2020, to December 31, 2020. The dependent variable in each multivariate regression is the Oxford-Man high frequency 5-minute realized volatility (in %) for the S&P/TSX Composite Index (*TSX_rvol5*). *Sentiment* is the weekly difference in Coronavirus Sentiment Index, obtained from the RavenPack Coronavirus Media Monitor (https://coronavirus.ravenpack.com/), which ranges between -100 and 100 and measures the level of sentiment across all entities mentioned in the news alongside the coronavirus. *SI* is the weekly difference in Stringency Index, obtained from the Oxford Coronavirus Government Response Tracker (OxCGRT; https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker), which measures the strictness of various containment and health measures taken in response to the pandemic using all 9 ordinal indicators in their database (C1 to C8, and H1). *R0* is the 7-day serial interval effective reproduction rate, from the Tracking R database (http://www.globalrt.live/), estimated using the SIR model with the time-varying growth rate determined using the Kalman filter from data on new cases. *OIL* is the weekly WTI oil futures return (in %). *GOLD* is the gold futures return (in %). Heteroskedasticity and autocorrelation (HAC) robust standard errors based on Newey and West (1987) are shown in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

TABLE 7
POOLED REGRESSIONS FOR THE IMPACT OF COVID-19 MEASURES ON THE S&P/TSX COMPOSITE INDEX HIGH FREQUENCY 5-MINUTE REALIZED VOLATILITY ON A NATIONAL AND REGIONAL LEVEL

	S&P/TSX Composite Index High Frequency 5-minute Realized Volatility					
	National	**Atlantic Provinces**	**Central Canada**	**Prairie Provinces**	**West Coast†**	**Northern Territories**
Intercept	-28.334 ***	-34.359 ***	-31.930 ***	-22.699 ***	-35.844 ***	-33.523 ***
	(4.622)	(5.652)	(4.826)	(4.750)	(7.348)	(4.045)
Sentiment	0.018	0.013	0.009	0.024	0.026	0.016
	(0.043)	(0.038)	(0.033)	(0.038)	(0.028)	(0.036)
SI	0.202 ***	0.303 ***	0.280 ***	0.117 *	0.365 **	0.244 ***
	(0.058)	(0.079)	(0.068)	(0.062)	(0.137)	(0.054)
R0	25.185 ***	24.040 ***	23.776 ***	25.344 ***	22.211 ***	27.626 ***
	(3.809)	(3.454)	(2.899)	(3.289)	(6.295)	(3.066)
OIL	0.013	0.001	0.016	0.019	0.001	0.008
	(0.045)	(0.044)	(0.032)	(0.043)	(0.053)	(0.038)
GOLD	0.107	-0.007	0.124	0.133	0.218	0.064
	(0.316)	(0.274)	(0.232)	(0.278)	(0.146)	(0.272)
Adj. R^2	0.702	0.740	0.692	0.669	0.694	0.693

† For the West Coast Region, the results shown above are for a multivariate regression given that the region only has one province, namely British Columbia.

Sample period is weekly from March 12, 2020, to December 31, 2020. The dependent variable in each pooled regression is the Oxford-Man high frequency 5-minute realized volatility (in %) for the S&P/TSX Composite Index (*TSX_rvol5*). *Sentiment* is the weekly difference in Coronavirus Sentiment Index, obtained from the RavenPack Coronavirus Media Monitor (https://coronavirus.ravenpack.com/), which ranges between -100 and 100 and measures the level of sentiment across all entities mentioned in the news alongside the coronavirus. *SI* is the Stringency Index, obtained from the Oxford Coronavirus Government Response Tracker (OxCGRT; https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker), measures the strictness of various containment and health measures taken in response to the pandemic using all 9 ordinal indicators in their database (C1 to C8, and H1). *R0* is the 7-day serial interval effective reproduction rate, from the Tracking R database (http://www.globalrt.live/), estimated using the SIR model with the time-varying growth rate determined using the Kalman filter from data on new cases. *OIL* is the weekly WTI oil futures return (in %). *GOLD* is the weekly gold futures return (in %). Robust clustered standard errors are shown in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

CONCLUSION

This study provides an assessment of various COVID-19 related measures and their impact on the S&P/TSX Composite Index return and volatility during the March to December 2020 period. We selected measures related to the infectiousness of the COVID-19 coronavirus, the stringency of the government polices put in place by the Canadian provincial and federal government in response to the COVID-19 pandemic, and the market sentiment regarding the coronavirus.

Using multivariate and pooled panel regressions for the analysis on a provincial and regional level, respectively, we find that the measures impacting stock return and volatility differ. While the S&P/TSX return was primarily driven by market sentiment, the S&P/TSX volatility was primarily driven by the information on the infectiousness of COVID-19. These results are counter to the commonly held belief of returns being driven by fundamental macroeconomic variables and volatility being driven by market sentiment but could potentially be attributed to the sudden and dramatic impact of COVID-19, causing a shift in investor behavior.

While this study does not provide conclusive evidence on the causal effects for the stock market return and volatility during the COVID-19 pandemic, it provides an indication of the primary drivers for the stock market movements observed during 2020 for the Canadian stock market. Additional analysis using alternative measures of market sentiment, separation of the analysis into sub-periods (or waves) to account for potential variation, and an investigation into other measures to include in our model would help to provide a more complete analysis. Furthermore, given that our research was conducted with a purely local market focus, future research that investigates potential contagion or spillover effects from neighboring countries or countries that have close economic ties to Canada is recommended.

ENDNOTES

1. We compared data provided by the Government of Canada to those provided by Johns Hopkins University Center for Systems Science and Engineering (JHU CSSE) and found differences in the infection numbers reported. We chose to use the JHU CSSE numbers for our analysis as it is believed to be more reliable and accurate.
2. For the national level analysis, all thirteen provinces and territories are grouped together into a single panel data. In terms of the regional level analysis, the provinces are grouped according to their regions. There are a total of five regions in Canada: Atlantic Region (Newfoundland and Labrador, Prince Edward Island, Nova Scotia), Central Canada (Ontario and Quebec), Prairie Provinces (Manitoba, Saskatchewan, Alberta), West Cost (British Columbia), and Northern Territories (Yukon, Northwest Territories, and Nunavut).
3. The Breusch-Pagan Lagrange Multiplier Test (Breusch and Pagan, 1980) was conducted on our panel data to test for heteroskedasticity and the results were insignificant. We obtained a p-value greater than 0.05, which means that the null hypothesis of homoskedasticity (i.e., the variance of the random effect is zero) is not rejected and the pooling method is recommended.

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APPENDIX

The table below provides the descriptions for the Oxford Coronavirus Government Response Tracker (OxCGRT) indicator variables and the data type taken from Hale et al. (2020). The indicators are constructed using data collected from publicly available sources (news articles, government press releases, government briefings). Further details on the indicators is available from Hale et al., (2020) and the Oxford Coronavirus Government Response Tracker GitHub repository (https://github.com/OxCGRT/covid-policy-tracker/blob/master/documentation/codebook.md).

TABLE A1
DESCRIPTION OF OXFORD CORONAVIRUS GOVERNMENT RESPONSE TRACKER (OXCGRT) INDICATOR VARIABLES

ID	Name	Description	Coding	Data Type	Targeted (T) or General (G) Flag
Containment and Closure Policies:					
C1	School Closing	Record closings of schools and universities	0 = No measures; 1 = Recommend closing; 2 = Require closing (only some levels or categories); 3 = Require closing all levels; Blank = No data	Ordinal	Yes (Binary flag for geographic scope)
C2	Workplace Closing	Record closings of workplaces	0 = No measures; 1 = recommend closing (or work from home); 2 = Require closing (or work from home) for some sectors; 3 = Require closing (or work from home) all-but-essential workplaces; Blank = No data	Ordinal	Yes (Binary flag for geographic scope)
C3	Cancellation of Public Events	Record cancelling public events	0 = No measures; 1 = Recommend cancelling; 2 = Require cancelling; Blank = No data	Ordinal	Yes (Binary flag for geographic scope)
C4	Restrictions on Gatherings	Record limits on gatherings	0 = No restrictions; 1 = Restrictions on very large gatherings (the limit is above 1000 people); 2 = Restrictions on gatherings between 100-1000 people; 3 = Restrictions on gatherings between 11-100 people; 4 = Restrictions on gatherings of 10 people or less; Blank = No data	Ordinal	Yes (Binary flag for geographic scope)
C5	Close Public Transport	Record closing of public transport	0 = No measures; 1 = Recommend closing (reduce volume/means/volume); 2 = Require closing (prohibit use)	Ordinal	Yes (Binary flag for geographic scope)

C6	Stay at Home Requirements	Record orders to "shelter-in- place" and otherwise confine to home.	0 = No measures; 1 = Recommend not leaving house; 2 = Require not leaving house with exceptions for daily exercise, grocery shopping, and 'essential' trips; 3 = Require not leaving house with minimal exceptions; Blank = No data	Ordinal	Yes (Binary flag for geographic scope)
C7	Restrictions on Internal Movement	Record restrictions on internal movement between cities/regions	0 = No measures; 1 = Recommend not to travel between regions/cities; 2 = Internal movement restrictions in place	Ordinal	Yes (Binary flag for geographic scope)
C8	Restrictions on International Travel	Record restrictions on international travel	0 - No measures; 1 = Screening; 2 = Quarantine arrivals from high-risk regions; 3 = Ban on high-risk regions; 4 = Total border closure; Blank = No data	Ordinal	No
Economic Policies:					
E1	Income Support	Record if the government is providing direct cash payments to people who lose their jobs or cannot work.	0 = No income support; 1 = Government is replacing less than 50% of lost salary (or if a flat sum, it is less than 50% median salary); 2 = Government is replacing 50% or more of lost salary (or if a flat sum, it is greater than 50% median salary); Blank = No data	Ordinal	Yes (Binary flag for sectoral scope)
E2	Debt/Contract Relief for Households	Record if govt. is freezing financial obligations (e.g., stopping loan repayments, or banning evictions)	0 = No; 1 = Narrow relief, specific to one kind of contract; 2 = Broad debt/contract relief	Ordinal	No
E3	Fiscal Measures	Announced economic stimulus spending	Record monetary value of fiscal stimuli in USD, including spending or tax cuts NOT included in *E4*, *H4*, or *H5*: 0 = None; Blank = No data	Non-Ordinal (USD)	No
E4	International Support	Announced offers of COVID-19 related aid spending to other countries	Record monetary value announced if additional to previously announced spending: 0 = No new spending that day; Blank = No data	Non-Ordinal (USD)	No

Health System Policies:					
H1	Public Information Campaign	Record presence of public information campaigns	0 = No COVID-19 public information campaign; 1 = Public officials urging caution about COVID-19; 2 = Coordinated public information campaign; Blank = No data	Ordinal	Yes (Binary flag for geographic scope)
H2	Testing Policy	Record gov. policy on who has access to testing	0 = No testing policy; 1 = Only those who both (a) have symptoms AND (b) meet specific criteria (e.g., key workers, admitted to hospital, contact with a known case, returned from overseas); 2 = Testing of anyone showing COVID-19 symptoms; 3 = Open public testing (e.g., “drive-through” testing for asymptomatic people); Blank = No data	Ordinal	No
H3	Contact Tracing	Record gov. policy on contact tracing after a positive diagnosis	0 = No contact tracing; 1 = Limited contact tracing - not done for all cases; 2 = Comprehensive contact tracing - done for all cases; Blank = No data	Ordinal	No
H4	Emergency Investment in Healthcare	Announced short-term spending on healthcare system, e.g., hospitals, masks, etc.	Record monetary value in USD of new short-term spending on health: 0 = No new spending that day; Blank = No data	Non-Ordinal (USD)	No
H5	Investment in Vaccines	Announced public spending on COVID-19 vaccine development	Record monetary value announced if additional to previously announced spending: 0 = No new spending that day; Blank = No data	Non-Ordinal	NA
H6	Facial Coverings	Record policies on the use of facial coverings outside the home	0 = No policy; 1 = Recommended; 2 = Required in some specified shared/public spaces outside the home with other people present, or some situations when social distancing not possible; 3 = Required in all shared/public spaces; 4 = Required outside the home at all times regardless of location or presence of other people	Ordinal	Yes (Binary flag for geographic scope)
H7	Vaccination Policy	Record policies for vaccine delivery for different groups	0 = No availability; 1 = Availability for ONE of following: key workers/clinically vulnerable groups/elderly groups; 2 = Availability for TWO of the groups; 3 = Availability for ALL of the groups; 4 = Availability for all three plus partial additional availability (select broad groups/ages); 5 = Universal availability	Ordinal	Yes (Binary flag for cost)