Do COVID-19 cases and government response to COVID-19 drive mispricing in cross-listed companies?

Miss Chomtarn Junanukul

An Independent Study Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science in Finance
Department of Banking and Finance
FACULTY OF COMMERCE AND ACCOUNTANCY
Chulalongkorn University
Academic Year 2021

ผลกระทบต่อการบิดเบือนของราคาหลักทรัพย์ของบริษัทที่มีการจดทะเบียนหลักทรัพย์ข้ามประเทศ จากจำนวนผู้ติดเชื้อไวรัสโควิด-19และการตอบสนองของรัฐบาลต่อเชื้อไวรัสโควิด-19

น.ส.ชมธาร จันทร์อนุกูล

สารนิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาการเงิน ภาควิชาการธนาคารและการเงิน
คณะพาณิชยศาสตร์และการบัญชี จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2564

Independent Study Title	Do COVID-19 cases and government response to COVID-19 drive mispricing in cross-listed companies?
By	Miss Chomtarn Junanukul
Field of Study	Finance
Thesis Advisor	Assistant Professor NATHRIDEE SUPPAKITJARAK, Ph.D.

Accepted by the FACULTY OF COMMERCE AND ACCOUNTANCY, Chulalongkorn University in Partial Fulfillment of the Requirement for the Master of Science

INDEPENDENT STUDY COMMITTEE

..... Chairman
()
..... Advisor
(Assistant Professor NATHRIDEE SUPPAKITJARAK, Ph.D.)
..... Examiner
(NARAPONG SRIVISAL, Ph.D.)
..... Examiner
(Assistant Professor SUPARATANA TANTHANONGSAKKUN, Ph.D.)

ชมธาร จันทร์อนุกูล : ผลกระทบต่อการบิดเบือนของราคาหลักทรัพย์ของบริษัทที่มีการจดทะเบียนหลักทรัพย์ข้ามประเทศ จากจำนวนผู้ติดเชื้อไวรัสโควิด-19และการตอบสนองของรัฐบาลต่อเชื้อไวรัสโควิด-19. (Do COVID-19 cases and government response to COVID-19 drive mispricing in cross-listed companies?) อ.ที่ปรึกษาหลัก : ผศ. ดร.นาถฤดี ศุภกิจจารักษ์

งานวิจัยนี้มีจุดประสงค์เพื่อวิเคราะห์ผลกระทบต่อผลตอบแทนของหุ้น, การบิดเบือนของราคาหลักทรัพย์และความผันผวนของการบิดเบือนของราคาหลักทรัพย์ของบริษัทที่มีการจดทะเบียนหลักทรัพย์ข้ามประเทศจากจำนวนผู้ติดเชื้อไวรัสโควิด-19และการตอบสนองของรัฐบาลต่อเชื้อไวรัสโควิด-19 โดยใช้ข้อมูลจากบริษัทแคนาดาที่มีการจดทะเบียนหลักทรัพย์ใน Toronto Stock Exchange และมีการจดทะเบียนหลักทรัพย์ข้ามประเทศใน New York Stock Exchange หรือ NASDAQ

ผลจากงานวิจัยแสดงให้เห็นว่าผลตอบแทนของหุ้นได้รับผลกระทบทางลบจากการเพิ่มขึ้นของจำนวนผู้ติดเชื้อไวรัสโควิด-19 และได้รับผลกระทบทางบวกจากการตอบสนองของรัฐบาลต่อเชื้อไวรัสโควิด-19 ทั้งในแคนาดาและสหรัฐอเมริกา สำหรับผลกระทบต่อการบิดเบือนของราคาหลักทรัพย์โดยใช้ราคาที่สูงกว่าของหลักทรัพย์จดทะเบียนในแคนาดาเทียบกับหลักทรัพย์จดทะเบียนในสหรัฐอเมริกาเป็นตัวแทนของการบิดเบือนของราคาหลักทรัพย์ ผลที่ออกมาแสดงให้เห็นว่าเมื่อใช้ตัวแปรการเพิ่มขึ้นจำนวนผู้ติดเชื้อไวรัสโควิด-19และการตอบสนองของรัฐบาลต่อเชื้อไวรัสโควิด-19 ของแต่ละประเทศเป็นคนละตัวแปรกัน เฉพาะการตอบสนองของรัฐบาลต่อเชื้อไวรัสโควิด-19 ของแคนาดาที่แสดงให้เห็นถึงผลกระทบทางบวกต่อการบิดเบือนของราคาหลักทรัพย์ เมื่อได้มีการวิเคราะห์เพิ่มเติมโดยใช้ตัวแปรเป็นผลต่างของการเพิ่มขึ้นจำนวนผู้ติดเชื้อไวรัสโควิด-19 และการตอบสนองของรัฐบาลต่อเชื้อไวรัสโควิด-19 ระหว่างแคนาดาและสหรัฐอเมริกา ผลที่ออกมาแสดงให้เห็นว่าผลต่างของการเพิ่มขึ้นของจำนวนผู้ติดเชื้อไวรัสโควิด-19มีผลกระทบทางลบต่อการบิดเบือนของราคาหลักทรัพย์ ในขณะที่ผลต่างของการตอบสนองของรัฐบาลต่อเชื้อไวรัสโควิด-19 มีผลกระทบทางบวกต่อการบิดเบือนของราคาหลักทรัพย์ และสำหรับผลกระทบต่อความผันผวนของการบิดเบือนของราคาหลักทรัพย์ ผลที่ออกมาแสดงให้เห็นว่าการเพิ่มขึ้นของจำนวนผู้ติดเชื้อไวรัสโควิด-19ในสหรัฐอเมริกา และการตอบสนองของรัฐบาลต่อเชื้อไวรัสโควิด-19ของทั้งแคนาดาและสหรัฐอเมริกามีผลกระทบทางบวกต่อความผันผวน

สาขาวิชา	การเงิน	ลายมือชื่อนิสิต .....
ปีการศึกษา	2564	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

6384009426 : MAJOR FINANCE
KEYWOR D: COVID-19, Cross-listed company, Mispricing

Chomtarn Junanukul : Do COVID-19 cases and government response to COVID-19 drive mispricing in cross-listed companies?. Advisor: Asst. Prof. NATHRIDEE SUPPAKITJARAK, Ph.D.

This research is to examine impact of COVID-19 cases and government response to COVID-19 to cross-listed companies' stock return, mispricing and volatility of the mispricing, using evidence from 164 Canadian companies' stocks listed on Toronto Stock Exchange (TSX shares) and cross-listed in New York Stock Exchange or NASDAQ (US shares).

Our results show that there is negative impact from growth of COVID-19 cases to stock return and positive impact from government response to COVID-19 to stock return in both Canada and US. As for impact to mispricing, using price premium of stock listed in Canada relative to US as a proxy, the results suggest that when we implemented separate variables of growth of COVID-19 cases and government response to COVID-19 for each country, only government response to COVID-19 in Canada was found to have significant positive impact to the price premium. We have further examined the impact by implemented variables of difference in COVID-19 cases growth and government response to COVID-19 between Canada and US instead of separate variables for each country, the results showed that difference in COVID-19 cases growth of Canada relative to US is significantly negatively related to the price premium while difference in government response to COVID-19 cases is significantly positively related to the price premium. As for impact to volatility of the price premium, COVID-19 cases growth in US and government response in both Canada and US are found to be positively related to volatility of the price premium.

Field of Study:	Finance	Student's Signature .....
Academic Year:	2021	Advisor's Signature .....

ACKNOWLEDGEMENTS

I would like to thank my advisor Asst. Prof. Dr. Nathridee Suppakitjarak and my committees Dr. Narapong Srivisal and Asst. Prof. Dr. Suparatana Tanthanongsakkun for all your advices, comments and suggestions on my special project.

Chomtarn Junanukul

TABLE OF CONTENTS

Page

Introduction

Background

COVID-19 pandemic first started around end of 2019 in China, Wuhan city, where the first infection was found. Among all pandemic occurred in humanity, COVID-19 is recognized as one of serious global pandemics. The casualties of the pandemic now exceeded 281 million confirmed cases, including more than 5 million deaths (as reported by World Health Organization as of 31 December 2021). Following the occurrence, the global pandemic attracted attention from researchers across the world to examine its impact in vary perspectives (cultural, health, science, psychology) including finance.

There are many financial literatures which found empirical evidence to support that COVID-19 have a significant negative impact to price in stock markets and stock market return (Ashraf 2020b; Erdem 2020; Harjoto, Rossi, Lee and Sergi 2020). On the other hand, many literatures also observed positive impact to price in stock markets and stock market return from government response to COVID-19 (Chang, Feng and Zheng 2021; Scherf, Matschke and Rieger 2021; Yang and Deng 2021). There are also literatures studying on the impact to (Ashraf 2020b) stock volatility and they found that the COVID-19 cases and government response to COVID-19 led to increase in stock volatility. Although COVID-19 pandemic caused damage for all countries over the world, due to many different factors (e.g. government reaction, policies taken, culture, etc.), the severity, number of cases and extent of the government response to the pandemic in each country are different. As a result, magnitude of the effect from COVID-19 that each countries' stock exchange

markets have to face vary from each other. This motivated us to examine the impact of COVID-19 in each country to mispricing or price differential of cross-listed companies' stocks which listed their stocks in different countries.

Cross-listed companies are companies that are listed their stocks in one or more stock exchange market of different countries. In past several decades, cross-listing gains more attention as it allows the companies to be able to access foreign stock exchange markets and gain some benefits from it. Corporate Finance Institute (CFI) has concluded benefits of the cross-listing as follows:

- Attracts new investors and allows access to more capital.
- Improves companies' corporate governance as it requires companies to develop explicit and distinct corporate governance.
- Allows companies to gain exposure and increases opportunity to attract better talent.
- Enhances the companies' reputation by being cross-listed in major exchanges (e.g. NYSE, London Stock exchange, Tokyo Stock Exchange).

Theoretically, the price of cross-listed companies' stocks in home country and foreign country should be similar due to the fact that they are derived from the same company, provide claims on exactly the same cash flows. In contrast with that, there are many findings of price differential of cross-listed companies, which in turn, can lead to arbitrage opportunities. Many researchers have investigated the factors that drive the price of cross-listed companies to deviate from the theory (e.g. stock liquidity, volatility or exchange rate) and attempted to provide explanation (Chan and Kwok 2005; Karolyi, Li and Liao 2009; Li and Ran 2020; Liu, Wu, Jiang and Fan

2021). However, there is only a few which examines effect of COVID-19 to cross-listed companies (Aharon, Baig and DeLisle 2021)

Objective

This research is to investigate impact from COVID-19 cases and government response to COVID-19 to stock return of cross-listed companies in each country (home country and foreign country), to mispricing in cross-listed companies and to volatility of the mispricing, using evidence from Canadian companies' stocks listed on Toronto Stock Exchange (TSX shares hereafter) and cross-listed in New York Stock Exchange (NYSE) or NASDAQ (US shares hereafter). In this research, we use price premium of home share relative to foreign share as a proxy for mispricing in cross-listed companies.

Contribution

As the aim of this study is to investigate mispricing in cross-listed companies (price difference and volatility), which may lead to arbitrage opportunity. This can be beneficial to arbitrageurs and investors in the markets.

Furthermore, although there are many financial literatures which study on the impact of COVID-19 to the financial markets, most of the literatures focus their study on the impact to specific country or impact to all countries as a whole in vary perspective, for example, return, volatility, liquidity, etc. (Ashraf 2020b; Huang and Liu 2021; Xu 2022). Only a few that study on difference in the impact or how the impact causes difference across countries (Engelhardt, Krause, Neukirchen and Posch 2021; Erdem 2020; Xie, Wang and Huynh 2021) and there is even less literatures that study impact of the pandemic to cross-listed companies.

This study will be a complement to the existing literatures studying impact of COVID19 or global crisis to stock markets and also to the existing literatures studying mispricing of cross-listed companies.

Literature Review

COVID-19 impact to stock markets

Since early 2020, when COVID-19 outbreak was declared as a global pandemic by the World Health Organization (WHO), COVID-19 has gained attention from financial researchers around the world and literatures studying on impact of the pandemic to financial markets have been growing rapidly.

COVID-19 has been found to affect financial markets in vary perspectives. Many literatures found a positive relationship between COVID-19 cases and stock markets' volatility i.e. increase of COVID-19 cases lead to increase of stock markets volatility (Albulescu 2020; Baig, Butt, Haroon and Rizvi 2021; Engelhardt, Krause, Neukirchen and Posch 2021). Chebbi, Ammer and Hameed (2021) examined COVID-19 impact to stock liquidity using evidence from S&P 500 and found significant negative impact from the daily COVID-19 case growth to stock liquidity, which is aligned with findings from Baig, Butt, Haroon and Rizvi (2021) and Haroon and Rizvi (2020).

Ones of the widely studied areas are the effect of COVID-19 to stock market return or price and stock volatility. There are many literatures which found empirical evidence to support that increase of COVID-19 cases has negative impact to stock market return and positive impact to stock volatility. Ashraf (2020b) examined the relationship between daily COVID-19 confirmed cases and deaths, and stock market returns in 64 countries during January 22, 2020 to April 17, 2020. They argued that the increase in number of COVID-19 confirmed cases in a country causes decline in

stock market returns and this occurrence is also observed for increase in number of COVID-19 deaths, however, with much less severity.

Evidence from Erdem (2020), which studied on the effect of COVID-19 to stock markets in 75 countries using growth in total number of COVID-19 confirmed cases per million and total number of COVID-19 deaths per million of each country, also supports this finding that markets are significantly negatively affected by the pandemic. Similar to Ashraf (2020b), they found that the effect of growth in the number of COVID-19 cases per million on stock returns is almost three times that of growth in the number of COVID-19 deaths per million. Furthermore, they found that the number of COVID-19 cases is positively related to stock index volatility. They also argued that the negative effect from growth of COVID-19 cases to stock markets is less in countries with more freedom. One of the suggested explanations to this finding is that it may be due to in less-free countries, investors may suspect that the number of COVID-19 cases is underreported which lead to unmeasurable uncertainty in the markets and this causes investors to overreact.

The negative impact of COVID-19 cases/deaths to stock markets return and positive impact to volatility can also be observed in many prior literatures (Al-Awadhi, Alsaifi, Al-Awadhi and Alhammadi 2020; Engelhardt, Krause, Neukirchen and Posch 2021; Harjoto, Rossi, Lee and Sergi 2020; Hatmanu and Cautisanu 2021).

Harjoto, Rossi, Lee and Sergi (2020) compared the impact from COVID-19 in emerging markets and developed markets and found that the markets react differently to COVID-19 outbreak, measured by daily percentages increase in COVID-19 cases and deaths. Consistent with above-mentioned literatures, they also found negative

shock from COVID-19 cases to stock markets, resulted in lower stock returns and higher volatility. However, from their findings, they concluded that the increase of COVID-19 deaths or daily mortality rate growth, though creates negative impact to stock markets in emerging market, was found to be insignificant in developed markets.

Engelhardt, Krause, Neukirchen and Posch (2021) has studied the impact of COVID-19 cases growth rate to stock market' volatility in high-trust and low-trust countries. Same as Harjoto, Rossi, Lee and Sergi (2020), they found that stock markets' volatility is positively related with COVID-19 cases growth rate. Furthermore, they also argued that the impact is significantly lower in high-trust countries. The significant positive impact of COVID-19 cases growth rate to stock markets' volatility can also be observed in Yousef (2020).

Apart from COVID-19 cases, many literatures also studied the impact from government response to COVID-19 to stock market return. Capelle-Blancard and Desroziers (2020) examined impact from lockdown measures taken in each country using stringency index and found significant positive effect from the stringency index to stock return. The stringency index is also commonly used as a proxy for government response to COVID-19 in many prior literatures which positive effect to stock market return were also reported (Chang, Feng and Zheng 2021; Scherf, Matschke and Rieger 2021; Yang and Deng 2021).

Yang and Deng (2021) also examined the governemnt response to COVID-19 effect from containment and health index and economic support index, which were also provided by Oxford Coronavirus Government Response Tracker (OxCGRT),

same as stringency index. However, containment and health index involved more health system policies than stringency index and economic supports only included income and debt relief support policies. They found similar effect to stock market return from containment and health index but reported insignificant impact from economic support index. This finding is also supported by evidence from Ashraf (2020b) which also examined impact from the indices and reported insignificant impact from econimic support index, one of proxies for governement response in the research, to stock market return.

Chang, Feng and Zheng (2021) further examined the impact of each indicator used in the above-mentioned indices calculation provided by Oxford Coronavirus Government Response Tracker (OxCGRT). They found that the indicators of containment/stay-at-home measures have significant positive impact to stock market returns. However, health system policy indicators is reported to have insignificant impact. Similar to above-mentioned literatures, Chang, Feng and Zheng (2021) also reported insignificant impact from economic support index to stock market returns.

Apart from the impact to price and stock return, Caporale, Kang, Spagnolo and Spagnolo (2021) also found that government response to COVID-19 is positively related to stock volatility i.e. government respone to COVID-19 lead to increase of stock volatility. They examined effect of the government response to COVID-19 to stock return and volatility, using monthly and daily frequency data. As per result from daily frequency analysis, stringency index, one of a proxy for government response, was found to have significant positive impact to stock volatility in both G7 and non-G7 countries. Similar to other literatures, the index was found to have significant

negative impact to stock return in non-G7 countries. However, in G7 countries, the index was found to have insignificant negative impact to stock return.

There are many literatures which found evidences supporting the negative impact of COVID-19 cases, and positive impact from government response to COVID-19 in each country to stock returns and the negative impact of both COVID-19 cases and government response to COVID-19 to stock volatility. The pandemic has spread throughout the world with almost no country left unaffected. However, in each country, the extent of the damage, the casualties and the extent of measures taken by government may vary from the others. This disparity may lead to different impact that each country's financial market has to face. The aim of this research is to examine whether the COVID-19 cases and government response to COVID-19 in each country can drive mispricing of cross-listed companies which listed in different stock exchange markets, in different countries.

Mispricing in cross-listed companies

Referring to law of one price, one of the fundamental economic theories, identical goods sold in different markets should have the same price, after taking currency exchange into consideration. Contrary to the theory, price disparity in cross-listed companies can be observed in real life. Various prior literatures have investigated factors causing cross-listed companies' stocks to deviate from theoretical parity in vary perspectives and several factors have been concluded as explanations to the mispricing, including liquidity. risk, differential demand, asymmetric information, etc. These factors are also commonly used as control variables in many literatures

studying the mispricing of cross-listed companies (Karolyi, Li and Liao 2009; Li and Ran 2020; Liu, Wu, Jiang and Fan 2021).

Chan and Kwok (2005) examined relationship between above-mentioned factors and domestic shares (A shares) price premium relative to foreign shares (B and H share), evidence from China. They also added lagged price premium as one of independent variable in their examination. From their findings, they conclude that lagged price premium, supply of foreign shares, liquidity of domestic shares and volatility of domestic and foreign shares are significantly positively related to A-share price premium. On the other hand, they found that supply of foreign shares, liquidity of foreign shares and market capitalization of companies' free-floating shares are negatively related to the A-share price premium.

However, there are not many literatures which study impact of the COVID-19 to cross-listed companies. Aharon, Baig and DeLisle (2021) examines the impact of government interventions related to COVID-19 to volatility and liquidity of cross-listed securities, evidence from American depository receipts (ADRs). From the results, they concluded that the government interventions are positively related with volatility and liquidity of cross-listed securities. Extending the investigation of the impact from COVID-19 related factors to cross-listed companies, this research study whether the daily new COVID-19 cases and government response to COVID-19 in each country can drive the mispricing of cross-listed companies, which is still left unexplored.

Hypothesis Development

As reported in many prior literatures, increase of COVID-19 cases causes negative impact to price and return of stocks in the markets. Many literatures also found that government response to COVID-19 causes positive impact to the stock price and return.

Therefore, our hypothesis 1 is that increase of COVID-19 cases will cause negative impact to stock return of cross-listed companies' stocks in each country (home country and foreign country). On the other hand, government response to COVID-19 will have positive impact to the stock return in each country.

HYPOTHESIS 1

H1.1 Increase of COVID-19 cases will cause negative impact to stock return of the companies in Canada and US

H1.2 Government response to COVID-19 is positively related to stock return of the companies in Canada and US

Due to difference in severity of COVID-19 situation (i.e. increase of COVID-19 cases) and difference in response to COVID-19 of government in each country, they can cause magnitude of the impact that each country has to face to be different from the others. Cross-listed companies list their stocks in different stock exchange markets, in different countries. Although the stocks listed in different markets are derived from the same company, mispricing i.e., price difference can be observed in many prior literatures studying on the mispricing in cross-listed companies.

As per findings from prior literatures, increase of COVID-19 cases in each country will cause the stock price in the country being lower. Therefore, using price premium of TSX share relative to US share as a proxy for mispricing, our hypothesis 2 is that the new COVID-19 cases in Canada (home country) will have negative impact to TSX share price premium relative to US share and the new COVID-19 cases in US (foreign country) will have positive impact to TSX share price premium relative to US share.

On the other hand, higher degree of government response to COVID-19 in each country will cause the stock price of the country being higher. Therefore, government response to COVID-19 in Canada (home country) will be positively related to TSX share price premium relative to US share and government response to COVID-19 in US (foreign country) will be negatively related to TSX share price premium relative to US share.

HYPOTHESIS 2

H2.1 Increase of COVID-19 cases in Canada cause negative impact to mispricing price premium of TSX shares relative to US shares.

H2.2 Increase of COVID-19 cases in US cause positive impact to price premium of TSX shares relative to US shares.

H2.3 Government response to COVID-19 in Canada is positively related to price premium of TSX shares relative to US shares.

H2.4 Government response to COVID-19 in US is negatively related to price premium of TSX shares relative to US shares.

There are also many literatures which examine impact from COVID-19 cases and government response to COVID-19 to stock volatility. In the prior literatures, both COVID-19 cases and government response to COVID-19 were found to be positively related to stock market return and price.

Therefore, our hypothesis 3 is that increase of COVID-19 cases in Canada and US will be positively related to volatility of TSX share price premium relative to US share. Similarly, government response to COVID-19 in Canada and US will be positively related to volatility of TSX share price premium relative to US share.

HYPOTHESIS 3

H3.1 Increase of COVID-19 cases in Canada is positively related to volatility of price premium of TSX shares relative to US shares.

H3.2 Increase of COVID-19 cases in US is positively related to volatility of price premium of TSX shares relative to US shares.

H3.3 Government response to COVID-19 in Canada is positively related to volatility of price premium of TSX shares relative to US shares.

H3.4 Government response to COVID-19 in US is positively related to volatility of price premium of TSX shares relative to US shares.

Data and Methodology

Data

New COVID-19 cases per million

In our research, firstly, we collected data of the daily new COVID-19 cases per million of Canada and US from Our World in Data website (https://ourworldindata.org/). We decided to use per million data to avoid effect from different size of country population. The data started from 22 January 2020 when the first COVID-19 case of US was confirmed. As we will use 1-day-lagged data of number of COVID-19 cases, our sample period is from 23 January 2020 until December 2021.

Government response to COVID-19 (Stringency index)

As for government response to COVID-19 in each country, following prior literatures studying on impact of the government response to COVID-19, we used "Stringency index" of Canada and US a proxy to measure government response to COVID-19 in each country (Chang, Feng and Zheng 2021; Scherf, Matschke and Rieger 2021; Yang and Deng 2021). The index is calculated and provided by Oxford Coronavirus Government Response Tracker (OxCGRT) using nine indicators of the lockdown/stay-at-home style measures: school closures, workplace closures, cancellation of public events, restrictions on public gatherings, closures of public transport, stay-at-home requirements, public information campaigns, restrictions on internal movements, and international travel controls.

Some literatures also examine the impact from government response to COVID-19 using “Containment and health index” and “Economic support index” which are also calculated by Oxford Coronavirus Government Response Tracker (OxCGRT). However, economic support index was reported to have insignificant impact to stock market return (Chang, Feng and Zheng 2021; Yang and Deng 2021). As for Containment and Health index, Chang, Feng and Zheng (2021) further argued that the health system policy indicators which were added to the index (apart from the ones already included in stringency index) were found to have insignificant effect to stock market returns. This implies that the additional health system policy indicators in containment and health index have insignificant impacts to stock market return.

Therefore, we decided to use stringency index collected from Oxford Coronavirus Government Response Tracker (OxCGRT) as a proxy for government response to COVID-19 in this research.

Cross-listed companies and daily closing price

As of 1 February 2022, there are 177 Canadian companies’ stock which are listed on Toronto Stock Exchange (TSX hereafter) and directly cross-listed in NYSE or NASDAQ stock exchange markets in US (US stock exchanges hereafter), data from Toronto Stock Exchange website. As checked, 13 companies are listed on TSX or US stock exchanges after 23 January 2020 causing incomplete data during the period before listing. Therefore, we excluded those companies and there are 164 companies left as our sample.

Canadian companies’ stock listed in Toronto exchange is one of main international listing in US stock exchanges which directly listed their stocks on the

US stock exchanges (non-ADR). Canadian and US stock exchanges also have the same trading period which are overlapped completely. Moreover, both Canada and US are developed countries and have high freedom index, thus, there will be no impact from the factors, which were found to have effect to COVID-19 impact to stock return in prior literatures (Erdem 2020; Harjoto, Rossi, Lee and Sergi 2020).

We collected daily closing price data and daily return index of the companies' stocks in TSX and US stock exchanges from Datastream.

Control variables

In this research, we also added other control variables commonly used in literatures studying on mispricing in cross-listed companies to control effect from other factors. We described data sources of our control variables which are calculated from or proxied by other data besides daily closing price. We will further explain all control variables in the models in *Model* section.

- **Liquidity:** Turnover ratio calculated from trading volume and number of shares outstanding. We collected trading volume data and number of shares outstanding from Datastream.
- **Asymmetric information**: Total free-floating market capitalization calculated from number of free-floating shares and daily closing price. The data can be collected from Datastream, sourced from Refinitiv. Definition of free-floating shares as per Refinitiv is number of shares outstanding deducted by treasury shares and shares held by strategic entities (if applicable).

- **Exchange rate**: USD/CAD exchange rate. We collected the USD/CAD data (the number of units of Canadian Dollar per unit of US Dollar) from Datastream.
- **Stock market return:** We used daily stock market index of S&P/TSX index for Canada and S&P500 index for US, data collected from Datastream.
- **Short term interest rate:** We used 90-day treasury bill rate as a proxy of short-term interest rate of Canada and US. We collected the data from U.S. Department of the Treasury website and Bank of Canada website

Methodology

We will conduct panel data regressions using dependent variable, independent variables, control variables and model as described in next section.

As our models of hypothesis 1 & 2 are with dynamic panel data (included lagged price premium or lagged daily stock return), we used Arellano-Bond estimator instead. The estimator was also used in Chang, Feng and Zheng (2021) which studied impact of government response to COVID-19 to stock market return. They argued that using general OLS model or traditional panel fixed effects model to estimate their model which includes lagged stock market returns will lead to a result with biasness. Therefore, they decided and suggested to use Arellano-Bond estimator to estimate model with dynamic panel data.

As for hypothesis 3, following prior literatures, we used fixed-effect estimator to estimate our model of hypothesis 3. As per Chan and Kwok (2005) and Wu, Hao and Lu (2017), fixed-effect estimator was used to examine mispricing in cross-listed companies in their researches as it takes into account the firm-specific effects. Liu, Wu, Jiang and Fan (2021) also argued that the price difference of cross-listed companies is correlated with firm-specific fixed effects and decided to use first-difference estimator to eliminate the endogeneity bias. Many prior literatures studying the impact of COVID-19 cases and/or government response to COVID-19 to stock return also controlled for the fixed-effect or using fixed-effect estimator in their regression (Engelhardt, Krause, Neukirchen and Posch 2021; Erdem 2020; Harjoto, Rossi, Lee and Sergi 2020; Hatmanu and Cautisanu 2021; Yang and Deng 2021).

Model

In this research, we perform testing on our hypothesizes by conducting methodology as described above to estimate below models. The variables included in the models are further described in next section.

Hypothesis 1

$$R_{CANi,t} = \alpha + \beta_1(CaseGRCAN_{t-1}) + \beta_2(StringencyCAN_t) + \beta_3(CaseGRCAN_{t-1}) * (StringencyCAN_t) + \beta_4(LiquidityCAN_{i,t}) + \beta_5(RiskCAN_{i,t}) + \beta_6 ln(MktCap_{i,t}) + \beta_7(R_{CANi,t-1}) + \beta_8(InterestCAN_t) + \beta_9(S\&PCAN_t) + u_t$$

$$R_{USi,t} = \alpha + \beta_1(CaseGRUS_{t-1}) + \beta_2(StringencyUS_t) + \beta_3(CaseGRUS_{t-1}) * (StringencyUS_t) + \beta_4(LiquidityUS_{i,t}) + \beta_5(RiskUS_{i,t}) + \beta_6 ln(MktCap_{i,t}) + \beta_7(R_{USi,t-1}) + \beta_8(InterestUS_t) + \beta_9(S\&PUS_t) + u_t$$

Hypothesis 2

$$Premium_{i,t} = \alpha + \beta_1(CaseGRCAN_{t-1}) + \beta_2(CaseGRUS_{t-1}) + \beta_3(StringencyCAN_t) + \beta_4(StringencyUS_t) + \beta_5(CaseGRCAN_{t-1}) * (StringencyCAN_t) + \beta_6(CaseGRUS_{t-1}) * (StringencyUS_t) + \beta_7(LiquidityCAN_{i,t}) + \beta_8(LiquidityUS_{i,t}) + \beta_9(RiskCAN_{i,t}) + \beta_{10}(RiskUS_{i,t}) + \beta_{11} ln(MktCap_{i,t}) + \beta_{12}(Premium_{i,t-1}) + \beta_{13}(ExchangeRate_t) + \beta_{14}(InterestCAN_t) + \beta_{15}(InterestUS_t) + u_t$$

Hypothesis 3

$$Volatility_{i,t} = \alpha + \beta_1(CaseGRCAN_{t-1}) + \beta_2(CaseGRUS_{t-1}) + \beta_3(StringencyCAN_t) + \beta_4(StringencyUS_t) + \beta_5(CaseGRCAN_{t-1}) * (StringencyCAN_t) + \beta_6(CaseGRUS_{t-1}) * (StringencyUS_t) + \beta_7(LiquidityCAN_{i,t}) + \beta_8(LiquidityUS_{i,t}) + \beta_9 ln(MktCap_{i,t}) + \beta_{10}(Premium_{i,1}) + \beta_{11}(InterestCAN_t) + \beta_{12}(InterestUS_t) + u_t$$

Dependent variable

Hypothesis 1 ($R_{CANi,t}$ & $R_{USi,t}$):

Dependent variable for our hypothesis 1 is daily stock return ($R_{CANi,t}$ & $R_{USi,t}$). The daily stock return is calculated using daily return index of stocks in Canada and US.

Hypothesis 2 ($Premium_{i,t}$):

We used price premium of TSX shares ($Premium_{i,t}$) as dependent variable. The price premium is calculated from daily closing price of the stocks in TSX ($P_{CANi,t}$) and US ($P_{USi,t}$*) in CAD using below equation. The price of US shares is calculated to CAD using USD/CAD exchange rate (*Exchange rate*).

Following Chan and Kwok (2005), Chan, Hong and Subrahmanyam (2008) and Liu, Wu, Jiang and Fan (2021), we use below equation to calculate the price premium.

$$Premium_t = \left(\frac{P_{CANi,t}}{P^*_{USi,t}} \right) - 1$$

$$P^*_{USi,t} = P_{USi,t} \times ExchangeRate_t$$

Hypothesis 3 (*Volatility*$_{i,t}$):

We decided to calculate daily volatility of price premium of TSX share relative to US share from GARCH model. In many financial literatures, GARCH (1,1) model is widely suggested and used to estimate daily volatility (Baig, Butt, Haroon and Rizvi 2021; Yousef 2020).

We followed prior literatures studying on stock volatility and measure daily volatility of the price premium using conditional variance estimated from the GARCH (1,1) model in this research, using equation as below.

$$Premium_{i,t} = \mu + \varepsilon_{i,t}$$

and

$$Volatility^2_{i,t} = \omega + \alpha\varepsilon^2_{i,t-1} + Volatility^2_{i,t-1} + e_{i,t}$$

where Premium$_{i,t}$ is the price premium of TSX share relative to US share; Volatility$^2_{i,t}$ is conditional variance; μ, ω, α, β are parameters estimated by GARCH(1,1) model; $\varepsilon_{i,t}$ is the residual; $e_{i,t}$ is error terms.

Main independent variables

- **Case (*CaseCAN*$_{t-1}$ & *CaseUS*$_{t-1}$)**:

  We used 1-day-lagged growth of COVID-19 cases per million (i.e. daily new cases per million divided by cumulative cases per million of COVID-19) in Canada and US as two separate independent variables. We

used cases per million data to avoid effect from difference in population of each country. We also use 1-day-lagged data because investors in the markets are normally informed of the information on following day.

- **Stringency (*$StringencyCAN_t$* & *$StringencyUS_t$*)**:

  As described in *Data* section, we use stringency index of Canada and US provided by Oxford Coronavirus Government Response Tracker (OxCGRT) as a proxy for government response. We added the stringency index as two separate independent variables, one for Canada and another for US.

- **Interaction terms (*$CaseGRCAN_{t-1}$*StringencyCAN$_t$* & *$CaseGRUS_{t-1}$*StringencyUS$_t$*):**

  We also added interaction terms between growth of COVID-19 cases and stringency index. As per Yang and Deng (2021), they used interaction term between logarithm of the total number of COVID-19 cases and stringency index and found that the interaction term is negatively related to stock return. Tran and Tran (2021) also found that the interaction term is positively related to stock volatility.

Control variables

Hypothesis 1 & 2

For hypothesis 1 and 2, we also added other control variables founded to affect price premium (discount) or mispricing in cross-listed companies. These factors are also commonly used as control variables in other existing literatures (Chan and Kwok 2005; Karolyi, Li and Liao 2009; Li and Ran 2020; Liu, Wu, Jiang and Fan 2021).

- **Liquidity (*$LiquidityCAN_{i,t}$* & *$LiquidityUS_{i,t}$*):**

The result from Chan, Hong and Subrahmanyam (2008) shows that liquidity in ADR (foreign share) have significant impact to ADR premium. The increase in liquidity of ADR in US market is positively related with ADR premium relative to price of home shares. On the other hand, the ADR premium is negatively related with liquidity of home share. These findings are also supported by Chan and Kwok (2005) and Li and Ran (2020).

In Chan, Hong and Subrahmanyam (2008), turnover ratio was used as one of proxies for liquidity. They concluded that turnover ratio of both home share and ADR (foreign share) are reported to have significant explanatory power to ADR price premium. Turnover ratio is also applied as a proxy for liquidity in Beckmann, Ngo and Wang (2015). Thus, following Chan, Hong and Subrahmanyam (2008), we calculated turnover ratio using below formula and used as a proxy for liquidity in this research.

$$Turnover_{i,t} = \frac{Trading\ volume_{i,t}}{Shares\ Outstandint_{i,t}}$$

- **Risk (*$RiskCAN_{i,t}$* & *$RiskUS_{i.t}$*):**

Chan and Kwok (2005), Karolyi, Li and Liao (2009) and Li and Ran (2020) examined the effect from risk and found that price premium of home share is positively related with volatility of home share and foreign share.

Similar to daily volatility of price premium estimated in hypothesis 3, we also follow prior literatures studying on stock volatility and measure daily volatility of stock return of Canada and US using the GARCH (1,1) model and use it as a control variables for models of hypothesis 1 & 2, equation as below.

$$R_{i,t} = \mu + \varepsilon_{i,t}$$

and

$$Risk_{i,t}^2 = \omega + \alpha\varepsilon_{i,t-1}^2 + \beta Risk_{i,t-1}^2 + e_{i,t}$$

where $R_{i,t}$ is the daily stock return; $Risk_{i,t}^2$ is conditional variance; μ, ω, α, β are parameters estimated by GARCH(1,1) model; $\varepsilon_{i,t}$ is the residual; $e_{i,t}$ is error terms.

In Karolyi, Li and Liao (2009) and Li and Ran (2020), they adopted a ratio of standard deviation of return of home share to foreign share. However, in Chan and Kwok (2005), they separately implemented two variables for volatility of home share and foreign share and found that both of them have significant positive effect to home share price premium.

Therefore, instead of using a risk differential ratio, we decided to separately estimate daily volatility of TSX share and US share return and added as two separated control variables to control effect from risk to the price premium.

- **Asymmetric information (*$MktCap_{i,t}$*)**:

Market capitalization of each company is also commonly used as a proxy for information asymmetry in existing literatures (Chan and Kwok 2005; Karolyi, Li and Liao 2009; Li and Ran 2020).

The rationale behind this is that the large companies are likely to disclose more information and easier for foreign investors to obtain the information. This is aligned with argument from Bailey and Jagtiani (1994) that it is easier for foreigners to obtain information of large, well-known companies and thus, firm size is positively related with price.

Therefore, higher market capitalization of the companies is expected to be negatively related with price difference of cross-listed companies as foreign investors are able to obtain information of the companies easier and in turn, require lower discount.

Based on result from Chan and Kwok (2005), free-floating market capitalization is a better proxy for information asymmetry than market capitalization of total shares. Therefore, we use the free-floating market capitalization (data in million CAD) calculated from number of free-floating shares multiplied by daily closing TSX price of each company as a proxy for information asymmetry. Following, Karolyi, Li and Liao (2009), $MktCap_{i,t}$ control variable in our model is in logs.

$$Free\ floating\ market\ capitalization_{i,t} = Numbers\ of\ free\ floating\ shares_{i,t} \times P_{NZXi,t}$$

- **Lagged premium ($Premium_{i,t-1}$) or Lagged daily stock return ($R_{CANi,t-1}$ & $R_{USi,t-1}$)**

Referring to Chan and Kwok (2005), lagged price premium is added to control for autocorrelation as recommended in Domowitz, Glen and Madhavan (1997). From their results, they found a significant positive impact from the lagged price premium.

In Chang, Feng and Zheng (2021) and Yang and Deng (2021), they also added lagged stock market return in their research studying impact of government response to COVID-19 to stock market return. They found that it is significantly negatively related to stock market return.

Therefore, we also added lagged price premium to our model of hypothesis 2. As for hypothesis 1, we also added lagged daily stock return of each country as one of control variable.

- **Exchange rate (*$ExchangeRate_t$*) – Hypothesis 2 only**:

  Following Li and Ran (2020), USD/CAD exchange rate is added as our control variable to control for change in the exchange rate. Chan and Kwok (2005), Wu, Hao and Lu (2017) and Liu, Wu, Jiang and Fan (2021) also included exchange rate change as one of the control variables in their researches. Exchange rate is not added as control variable in hypothesis 1 as the it is to study the impact to each country.

- **Stock market return (*$S\&PCAN_t$ & $S\&PUS_t$*) – Hypothesis 1 only**

  We also added stock market return to control for effect to stock return of each company. Stock market return was found to have significant impact to companies' stock return in many prior literatures studying on stock return. We calculated stock market return from stock market index of Canada and US.

Apart from above-mentioned control variables, we also added interest rate as our control variables to control for effect from interest rate change during COVID-19 pandemic.

- **Interest rate (*$InterestCAN_t$* & *$InterestUS_t$*):**

  During COVID-19, government in many countries, including Canada and US, decided to reduce their interest policy rate.

Hatmanu and Cautisanu (2021) examined the impact from monetary policy interest rate reduction using monetary policy interest rates by central banks and found negative and significant impact to stock market index i.e. decrease in the monetary policy interest rates lead to increase of stock market index, which is also supported by findings from Capelle-Blancard and Desroziers (2020) and Caporale, Kang, Spagnolo and Spagnolo (2021). Capelle-Blancard and Desroziers (2020) used daily change in key interest rate of central banks to examine lower policy interest rates in 74 countries and found significant negative impact to stock market indices.

Bissoon, Seetanah, Bhattu-Babajee, Gopy-Ramdhany and Seetah (2016) used interest rate as a proxy of monetary policy tools and studied the impact to stock return using panel regression and found significant negative impact of the interest rate to stock return. This finding is also supported by Ioannidis and Kontonikas (2007) which used short-term interest rate to measure monetary policy. In the literature, they used 3-month treasury bill as a proxy for short-term interest rate and suggested that it is significantly correlated with central bank interest rate instruments and thus, implemented it as a measure for monetary policy.

Following Ioannidis and Kontonikas (2007), we added short-term interest rate, using 3-month treasury bill rate of Canada and US, as our control variables to control effect from the interest rate reduction or change.

Hypothesis 3

In our model of hypothesis 3 examining the impact from COVID-19 cases and government response to COVID-19 to volatility of price premium of TSX share relative to US share, we added below variables which were found to have impact to stock volatility as our control variables to control the effect to volatility of price premium. The proxy or calculation for the variables is the same as described in control variables of hypothesis 1 & 2.

Aharon, Baig and DeLisle (2021), which examined impact of COVID-19 cases and government intervention to stock volatility, has included below factors in their research and found that the factors have significant impact to the volatility.

Price premium of TSX share relative to US share ($Premium_{i,t}$)

They used natural logarithm of stock price and found that it has significant negative impact to stock price volatility. In this research, we use price premium of TSX share relative to US share.

Liquidity ($LiquidityCAN_{i,t}$ & $LiquidityUS_{i,t}$)

They found that turnover ratio is positively related to volatility and illiquidity ratio is negatively related to volatility. This implies that stock volatility is positively related to stock liquidity. In this research, we used turnover ratio as a proxy for liquidity.

Asymmetric information ($MktCap_{i,t}$)

In Aharon, Baig and DeLisle (2021), they used natural logarithm of market capitalization to control for effect from firm size and they found that it

is negatively related to stock volatility. Therefore, in this research, we also control effect from company size using free-floating market capitalization as a proxy.

Same as models of hypothesis 1 & 2, we also added interest rate as one of our control variables in model of hypothesis 3 to control for effect from interest rate reduction or change during COVID-19 pandemic.

Interest rate (*$InterestCAN_t$ & $InterestUS_t$*)

Albaity (2011) has examined effect of interest rate as one of the monetary policy tools to volatility of stock market index and found that the interest rate is negatively related to stock market volatility. In this research, we use 3-month treasury bill rate of Canada and US as a proxy for short-term interest rate to measure monetary policy.

We have summarized our expectation on coefficients of our main independent variable in Table 1.

As checked data of variables of our models, we found few observations with outlier in the data of our variables. We have presented descriptive statistics of our data in Table 2 and presented quartiles of our data in Table 3. Figure 1-4 are histogram graphs of our dependent variables. There are small number of observations with outliers in data of our dependent variables (i.e. $Premium_{i,t}$, $R_{CANi,t}$, $R_{USi,t}$, $Volatility_{i,t}$) and some control variables (i.e. $RiskCAN_{i,t}$, $RiskUS_{i,t}$, $LiquidityUS_{i,t}$, $MktCap_{i,t}$) as we can observe in the Table 2 that there are extreme values exist in the data when

compared minimum and maximum values with the 1st percentile and 99th percentile, respectively. For example, we can see the maximum value of $LiquidityUS_{i,t}$ is 19.4723 which is very far from 99th percentile which is 0.0825. However, for the $MktCap_{i,t}$, as per our model, the variable will be standardized by taking natural logarithm before performing regression. We have performed further checking for some extreme values to ensure the outliers is not from error. Thus, we decided to not drop the observations with outlier data in our research as they are from actual data.

As per Huang and Liu (2021) and Caporale, Kang, Spagnolo and Spagnolo (2021), to control for outlier, they performed data winsorization for all continuous variables in their research at 1st and 99th percentile. Following the literatures, in this research, we decided to also perform regression for the data after winsorization for variables with outliers mentioned previously at the 1st and 99th percentile for our models of hypothesis 1-3 and show the results together with regression results from pre-winsorized data in empirical results section. Winsorization method is also commonly used in many prior financial literatures to avoid effect from outlier (Beckmann, Ngo and Wang 2015; Tran and Tran 2021; Wu, Hao and Lu 2017).

Table 1: Expectation on coefficients of variables

This table reports our expectation on coefficients of main independent variables in our models. Panel A shows our expectation on coefficients of variables in models of hypothesis 1. Panel B shows our expectation on coefficients of variables in model of hypothesis 2. Panel C shows our expectation on coefficients of variables in model of hypothesis 3.

Panel A: Hypothesis 1	
Variables	**Expectation**
$\beta_1(CaseGRCAN_{t-1})$	Negative
$\beta_2(StringencyCAN_t)$	Positive
$\beta_1(CaseGRUS_{t-1})$	Negative
$\beta_2(StringencyUS_t)$	Positive
Panel B: Hypothesis 2	
Variables	**Expectation**
$\beta_1(CaseGRCAN_{t-1})$	Negative
$\beta_2(CaseGRUS_{t-1})$	Positive
$\beta_3(StringencyCAN_t)$	Positive
$\beta_4(StringencyUS_t)$	Negative
Panel C: Hypothesis 3	
Variables	**Expectation**
$\beta_1(CaseGRCAN_{t-1})$	Positive
$\beta_2(CaseGRUS_{t-1})$	Positive
$\beta_3(StringencyCAN_t)$	Positive
$\beta_4(StringencyUS_t)$	Positive

Table 2: Descriptive statistics of dependent variables, main independent variables and control variables

This table reports descriptive statistics of dependent variables, main independent variables and control variables in our models.

	Unit	Obs	Mean	Standard Deviation	1st percentile	99th percentile	Minimum	Maximum
$Premium_{i,t}$	% in decimals form	78,720	-0.0029	0.0338	-0.0486	0.0323	-0.5496	0.7495
$R_{CANi,t}$	% in decimals form	78,720	0.0013	0.0472	-0.1161	0.1429	-0.7238	2.0000
$R_{USi,t}$	% in decimals form	78,720	0.0013	0.0479	-0.1195	0.1441	-0.7209	1.7500
$Volatility_{i,t}$	% in decimals form	78,720	0.0083	0.0111	0.0021	0.0497	0.0005	0.5286
$CaseGRCAN_{t-1}$	% in decimals form	78,720	0.0349	0.1228	0.0000	0.8560	0.0000	1.2204
$CaseGRUS_{t-1}$	% in decimals form	78,720	0.0485	0.2349	0.0000	0.8824	0.0000	4.0000
$StringencyCAN_t$	Points	78,720	52.4346	14.6739	11.1100	75.9300	11.1100	75.9300
$StringencyUS_t$	Points	78,720	58.2578	16.5586	0.0000	75.4600	0.0000	75.4600
$RiskCAN_{i,t}$	% in decimals form	78,720	0.0402	0.0295	0.0069	0.1402	0.0008	1.0345
$RiskUS_{i,t}$	% in decimals form	78,720	0.0413	0.0284	0.0083	0.1294	0.0001	1.7322
$LiquidityCAN_{i,t}$	% in decimals form	78,720	0.0032	0.0049	0.0000	0.0204	0.0000	0.3012
$LiquidityUS_{i,t}$	% in decimals form	78,720	0.0091	0.0803	0.0000	0.0825	0.0000	19.4723
$MktCap_{i,t}$	Million CAD	78,720	10,771.50	23,830.28	27.61	118,475.00	2.37	329,308.67
$ExchangeRate_t$	CAD	78,720	1.2977	0.0555	1.2066	1.4354	1.2019	1.4539
$InterestCAN_t$	% in decimals form	78,720	0.0023	0.0036	0.0003	0.0164	0.0000	0.0165
$InterestUS_t$	% in decimals form	78,720	0.0016	0.0034	0.0001	0.0155	-0.0005	0.0156
S&PCANt	% in decimals form	78,720	0.0005	0.0158	-0.0526	0.0383	-0.1234	0.1196
S&PUSt	% in decimals form	78,720	0.0007	0.0167	-0.0518	0.0600	-0.1198	0.0938

Table 3: Quartile of dependent variables, main independent variables and control variables

This table reports data of dependent variables, main independent variables and control variables in our models in quartile.

	Unit	Obs	Mean	1st quartile	2nd quartile	3rd quartile	Minimum	Maximum
$Premium_{i,t}$	% in decimals form	78,720	-0.0029	-0.0032	-0.0003	0.0022	-0.5496	0.7495
$R_{CANi,t}$	% in decimals form	78,720	0.0013	-0.0174	0.0000	0.0164	-0.7238	2.0000
$R_{USi,t}$	% in decimals form	78,720	0.0013	-0.0180	0.0000	0.0174	-0.7209	1.7500
$Volatility_{i,t}$	% in decimals form	78,720	0.0083	0.0029	0.0045	0.0100	0.0005	0.5286
$CaseGRCAN_{t-1}$	% in decimals form	78,720	0.0349	0.0024	0.0056	0.0146	0.0000	1.2204
$CaseGRUS_{t-1}$	% in decimals form	78,720	0.0485	0.0023	52.7800	0.0149	0.0000	4.0000
$StringencyCAN_t$	Points	78,720	52.4346	45.8300	0.0059	62.0400	11.1100	75.9300
$StringencyUS_t$	Points	78,720	58.2578	52.3100	62.5000	68.9800	0.0000	75.4600
$RiskCAN_{i,t}$	% in decimals form	78,720	0.0402	0.0240	0.0367	0.0489	0.0008	1.0345
$RiskUS_{i,t}$	% in decimals form	78,720	0.0413	0.0257	0.0379	0.0500	0.0001	1.7322
$LiquidityCAN_{i,t}$	% in decimals form	78,720	0.0032	0.0009	0.0020	0.0038	0.0000	0.3012
$LiquidityUS_{i,t}$	% in decimals form	78,720	0.0091	0.0011	0.0033	0.0083	0.0000	19.4723
$MktCap_{i,t}$	Million CAD	78,720	10,771.50	298.95	1563.41	7996.32	2.37	329,308.67
$ExchangeRate_t$	CAD	78,720	1.2977	1.2570	1.2804	1.3320	1.2019	1.4539
$InterestCAN_t$	% in decimals form	78,720	0.0023	0.0010	0.0013	0.0018	0.0000	0.0165
$InterestUS_t$	% in decimals form	78,720	0.0016	0.0005	0.0008	0.0011	-0.0005	0.0156
S&PCANt	% in decimals form	78,720	0.0005	-0.0040	0.0015	0.0060	-0.1234	0.1196
S&PUSt	% in decimals form	78,720	0.0007	-0.0048	0.0016	0.0078	-0.1198	0.0938

Figure 1: Histogram graph - Stock return of Canada

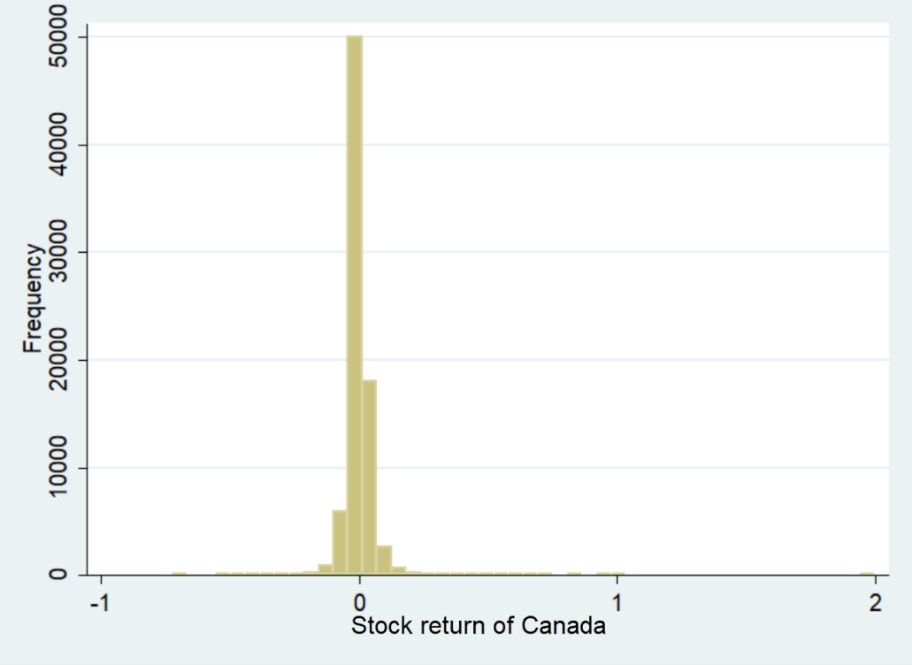


Figure 2: Histogram graph – Stock return of US

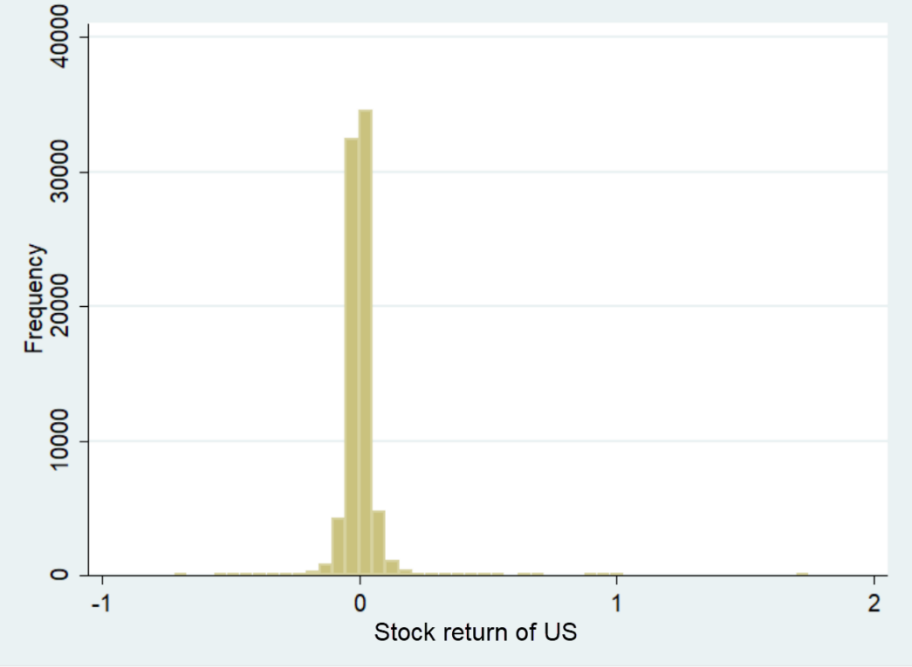


Figure 3: Histogram graph – Price premium of TSX shares relative to US shares

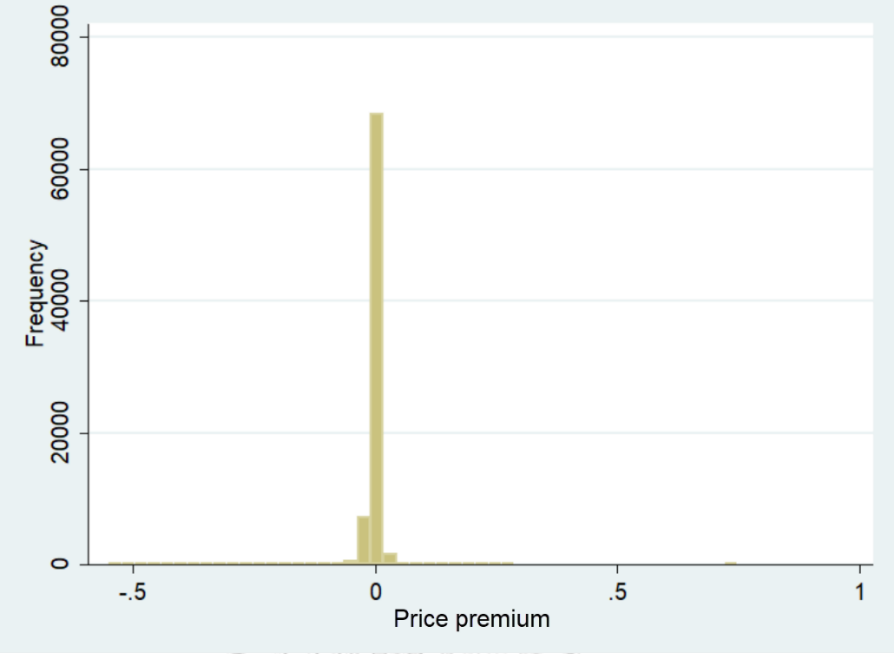
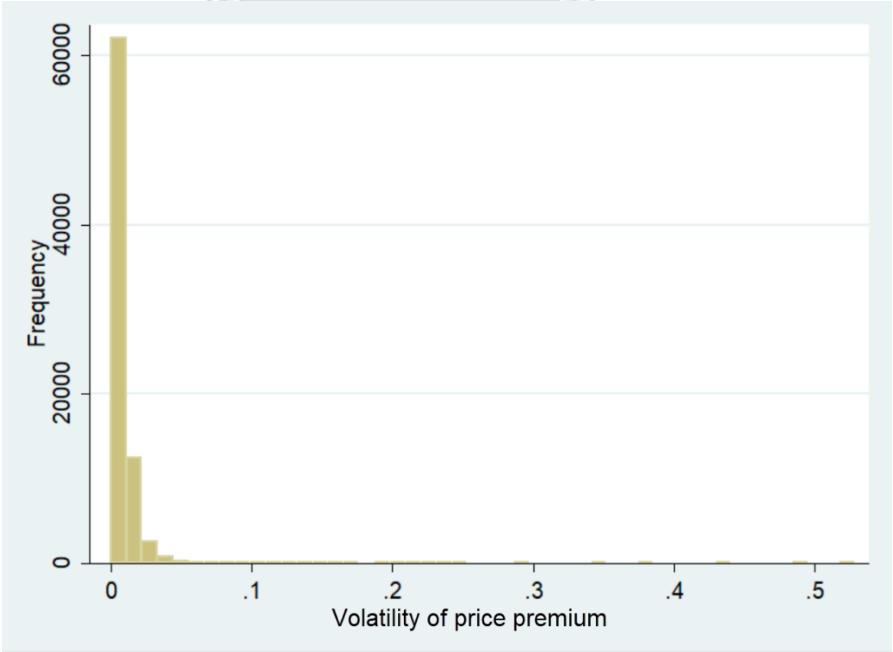


Figure 4: Histogram graph – Volatility of price premium of TSX shares relative to US shares



Empirical results

In this section, we present our regression results for each hypothesis using data and methodology as described in previous sections.

HYPOTHESIS 1

Table 4 presents our results based on models of hypothesis 1, using Arellano-Bond estimator.

H1.1 Increase of COVID-19 cases will cause negative impact to stock return in each country

H1.2 Government response to COVID-19 is positively related to stock return in each country

Canada

Column (1) shows regression results from pre-winsorized data of Canada and TSX shares. From the results, growth of COVID-19 cases has significant negative impact to stock return. On the other hand, a result for expected positive impact from stringency index to stock return as per our hypothesis 1.2 was found to be insignificant in this case which indicated that in case of Canada, the increase of stringency in government measures with lockdown/stay-at-home style do not give direct positive impact to stock markets in terms of stock return. However, as per our result, the interaction term between growth of COVID-19 cases and stringency index was found to be significantly and positively related to stock return. This can be

implied that the government response to COIVD-19 can help weaken the negative impact to stock return from growth of COVID-19 cases.

Our result for the impact from growth of COVID-19 cases is aligned with many existing literatures studying on the impact of COVID-19 cases to stock market return or price (Ashraf 2020b; Erdem 2020; Harjoto, Rossi, Lee and Sergi 2020) which argued that COVID-19 cases is negatively related to the stock market return or price. However, the result for impact from government response or stringency index is not aligned with most of the existing literatures studying which found direct significant positive impact from government response to COVID-19 to stock market return or price (Chang, Feng and Zheng 2021; Yang and Deng 2021).

However, aligned with our finding, there are also some other previous literatures which did not observe significant positive impact from the stringency index to stock market return or price. For example, Ashraf (2020a), they used stringency index as a proxy for social distancing measures and from their results, they argued that there is direct negative impact from the social distancing measures to stock market returns. They suggested that this may be due to market's expected negative impact from the government measures on economic activity. On the other hand, they suggested that there is still indirect positive impact from the social distancing measures to stock market returns through decrease of COVID-19 cases. As for Scherf, Matschke and Rieger (2021), they also found negative impact from the stringency index to stock abnormal return and argued that when governments introduced stricter preventive measures to contain spread of COVID-19, stock markets negatively reacted to the increase of stringency and caused decrease in stock returns. However,

they also argued that this may be due to market's delayed response (initial underreaction) as they found that after couple of three days of the introduction of stricter measures, the abnormal returns started to become positive for a few days.

Column (2) shows regression results of hypothesis 1 from using winsorized data of Canada. After using winsorized data, the results as shown in Column (2) are different from regression results estimated from pre-winsorized data, as shown in Column (1). Growth of COVID-19 cases and the interaction term were found to become insignificant.

US

As for results from data of US and US shares as shown in Column (3), aligned with many previous literatures, the results show that growth of COVID-19 cases and stringency index have significant negative and positive impact to stock returns, respectively. Our regression results from US data, both for impact from COVID-19 cases and impact from stringency index (proxy of government response to COVID-19) to stock market return, are aligned with the existing literatures mentioned previously which studied on impact of COVID-19 cases to stock market return or price (Ashraf 2020b; Erdem 2020; Harjoto, Rossi, Lee and Sergi 2020) and impact of government response to stock market return or price (Chang, Feng and Zheng 2021; Yang and Deng 2021). In this case, same as case of Canada, we also observed the significant positive impact from the interaction term between growth of COVID-19 cases and government response to COVID-19 to stock return.

In US case, results from pre-winsorized data, shown in Column (3), and winsorized data, shown in Column (4), are aligned for growth of COVID-19 cases and the interaction term between growth of COVID-19 cases and stringency index i.e. there is no change in the observed significant negative/positive impact or the insignificant impact. Nevertheless, there are differences in estimated values of coefficients and significance level of the variables. As for the result of government response to COVID-19, the variable became insignificant in this case which means that we can only observe the impact from the government response to COVID-19 through the interaction term i.e. it weaken the negative impact from growth of COVID-19 cases.

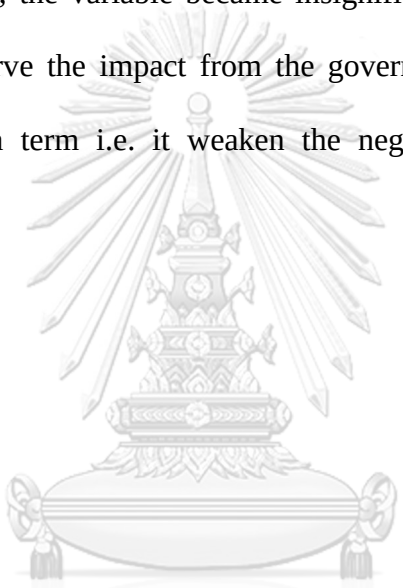


Table 4: Regression results – Hypothesis 1 – Impact from growth of COVID-19 cases and stringency index to stock return in Canada and US

VARIABLES	(1) Canada Before winsorization	(2) Canada After winsorization	(3) US Before winsorization	(4) US After winsorization
$CaseGRCAN_{t-1}$	-0.0649**	-0.0380		
	(0.0393)	(0.0466)		
$StringencyCAN_t$	-7.16e-05	-6.99e-05		
	(0.000139)	(0.000153)		
$CaseGRCAN_{t-1}$*$StringencyCAN_t$	0.00367**	0.00248		
	(0.00178)	(0.00210)		
$CaseGRUS_{t-1}$			-0.108***	-0.124**
			(0.0455)	(0.0497)
$StringencyUS_t$			0.000198**	7.29e-05
			(0.000106)	(0.000108)
$CaseGRUS_{t-1}$*$StringencyUS_t$			0.00347**	0.00403***
			(0.00141)	(0.00155)
$InterestCAN_t$	-0.322	-0.540		
	(0.581)	(0.630)		
$RiskCAN_{i,t}$	-0.221***	-0.168***		
	(0.0323)	(0.0236)		
$LiquidityCAN_{i,t}$	1.231***	1.139***		
	(0.181)	(0.195)		
$R_{CANi,t-1}$	-0.0518***	-0.0663***		
	(0.0150)	(0.0154)		
$S\&PCAN_t$	0.998***	0.856***		
	(0.0379)	(0.0379)		
$InterestUS_t$			1.392***	0.889**
			(0.432)	(0.356)
$RiskUS_{i,t}$			-0.194***	-0.232***
			(0.0279)	(0.0270)
$LiquidityUS_{i,t}$			0.0761***	0.238***
			(0.0241)	(0.0749)
$R_{USi,t-1}$			-0.0348**	-0.0537***
			(0.0155)	(0.0178)
$S\&PUS_t$			0.917***	0.803***
			(0.0286)	(0.0273)
$\ln(MktCap_{i,t})$	-0.00135***	-0.00107***	-0.000642***	-0.000742***
	(0.000196)	(0.000187)	(0.000147)	(0.000157)
Constant	0.0174**	0.0145	-0.00307	0.00577
	(0.00807)	(0.00907)	(0.00667)	(0.00679)

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

HYPOTHESIS 2

Table 5 presents our results based on models of hypothesis 2, using Arellano-Bond estimator.

H2.1 Increase of COVID-19 cases in Canada cause negative impact to price premium of TSX shares relative to US shares.

H2.2 Increase of COVID-19 cases in US cause positive impact to price premium of TSX shares relative to US shares.

H2.3 Government response to COVID-19 in Canada is positively related to price premium of TSX shares relative to US shares.

H2.4 Government response to COVID-19 in US is negatively related to price premium of TSX shares relative to US shares.

Column (1) shows regression results of hypothesis 2 from using pre-winsorized data. As per the regression results, only coefficient of government response and interaction term between growth of COVID-19 cases and government response to COVID-19 of Canada were found to be significant. This suggests that government response to COVID-19 Canada significantly leads to increase in price premium of TSX shares relative to US shares. On the other hand, growth of COVID-19 cases showed the negative impact through the interaction term which reduce the positive effect from the government response to COVID-19 of Canada. Our result for government response to COVID-19 of Canada supports results from previous literatures (Ashraf 2020a; Erdem 2020; Harjoto, Rossi, Lee and Sergi 2020) in terms of impact to each country. They argued that increase of COVID-19 cases caused

negative impact to stock price. As a result of the positive impact from government response to COVID-19 to stock return and price of Canada, it leads to positive impact to the price premium of TSX share relative to US share.

As for other main variables (i.e. growth of COVID-19 cases of Canada and US, stringency index of US), our regression results show no statistical evidence to support our hypothesis 2.1-2.2 and 2.4 which state that COVID-19 cases growth of US is positively related to the price premium and on the other hand, COVID-19 cases growth of Canada and government response (stringency index) of US are negatively related to the price premium, though, there is still negative impact from the COVID-19 cases growth of Canada via interaction term. In perspective of impact in each country which lead to impact to the price premium as described in our hypothesis development, our results for impact from growth of COVID-19 cases of US, stringency index of Canada and stringency index of US seem to not be aligned with some existing literatures studying on impact from COVID-19 cases (Ashraf 2020a; Erdem 2020; Harjoto, Rossi, Lee and Sergi 2020) and government response (Chang, Feng and Zheng 2021; Yang and Deng 2021) to stock market return or price. However, there are also some existing literatures that supported our results as they also did not observe significant negative impact to stock market return or price from COVID-19 cases (Harjoto, Rossi, Lee and Sergi 2020; Scherf, Matschke and Rieger 2021) or positive impact to stock market return or price from government response (Ashraf 2020a; Scherf, Matschke and Rieger 2021).

As per our regression results of hypothesis 2 in Column (2) from using winsorized data, government response to COVID-19 and the interaction term of

Canada were found to become insignificant. On the other hand, we observed significant positive impact from government response to COVID-19 and the interaction term of US which was found to be insignificant in results from pre-winsorized data. As for other main independent variables, the results of observed significant positive/negative or insignificant impact are aligned with results from pre-winsorized data.

Use difference between countries as a variable instead of separate variables for each country

As per our hypothesis 2 development, we expected that the price premium will be positively related to increase of COVID-19 cases and negatively related to stringency index of US (foreign country) due to their negative and positive impact to stock return or price of foreign country, respectively. As well as the case of expected negative impact from growth of COVID-19 cases of Canada (home country), we expected the direct negative impact from the variable to the price premium due to its negative impact to stock return and price of home country. Thus, our regression results for hypothesis 2 for the above-mentioned variables seem to be in contrast with some existing literatures in terms of impact in each country and also not aligned with our results in hypothesis 1.

We suspected that implementing 2 separate variables for COVID-19 cases growth each country and 2 separate variables for stringency index of each country may cause the results to unclearly represent how the difference in severity of COVID-19 situation or cases and in magnitude of government response to COVID-19 between home country and foreign country can affect mispricing of cross-listed companies. This might be due to some period in our sample period, the values of both countries are on the same direction with similar trend. Figure 5 and 6 compare growth of COVID-19 cases of Canada and US in 2020 and 2021, respectively. Figure 7 and 8 compare stringency index of Canada and US in 2020 and 2021, respectively.

Figure 5: Growth of COVID-19 cases of Canada and US

23 March 2020 – 31 December 2020

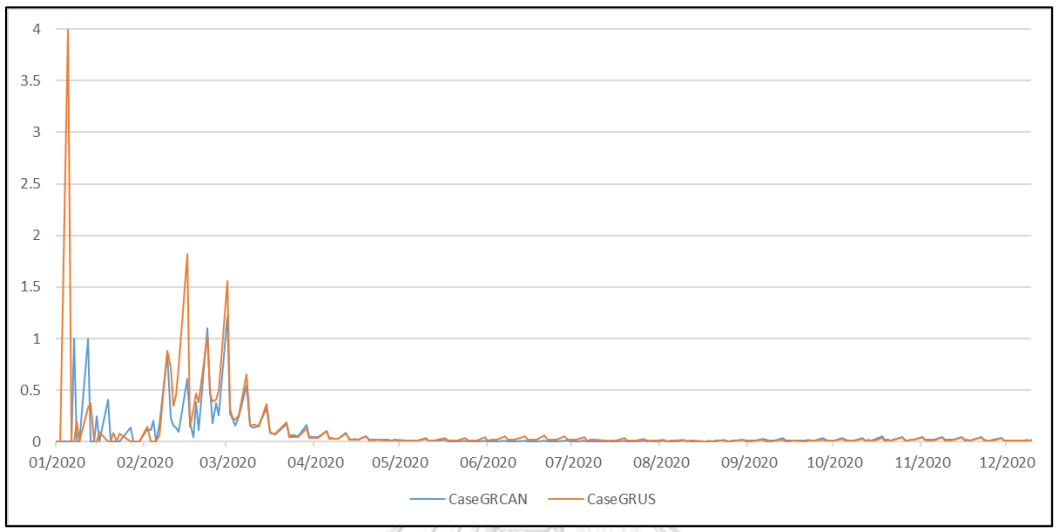


Figure 6: Growth of COVID-19 cases of Canada and US

1 January 2021 – 31 December 2021

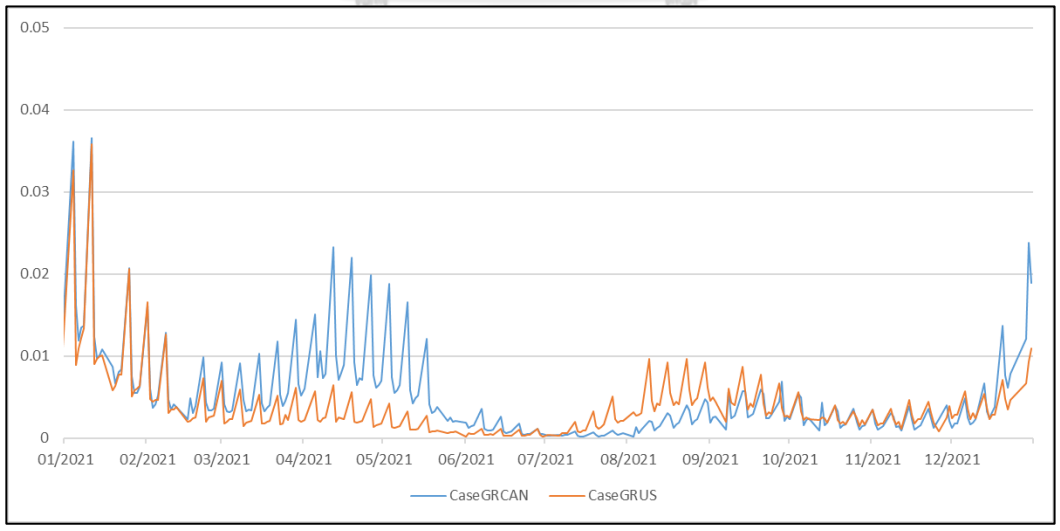


Figure 7: Stringency index of Canada and US

23 March 2020 – 31 December 2020

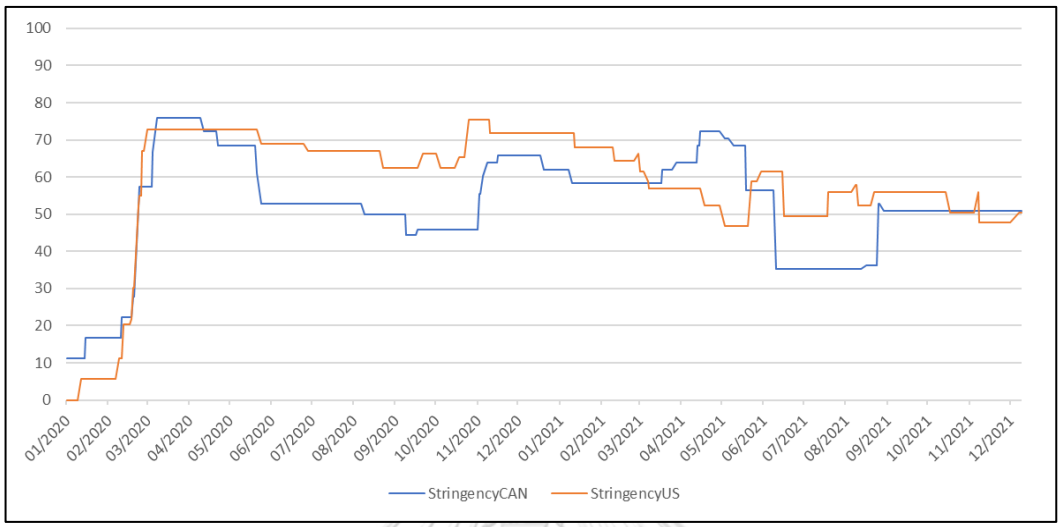
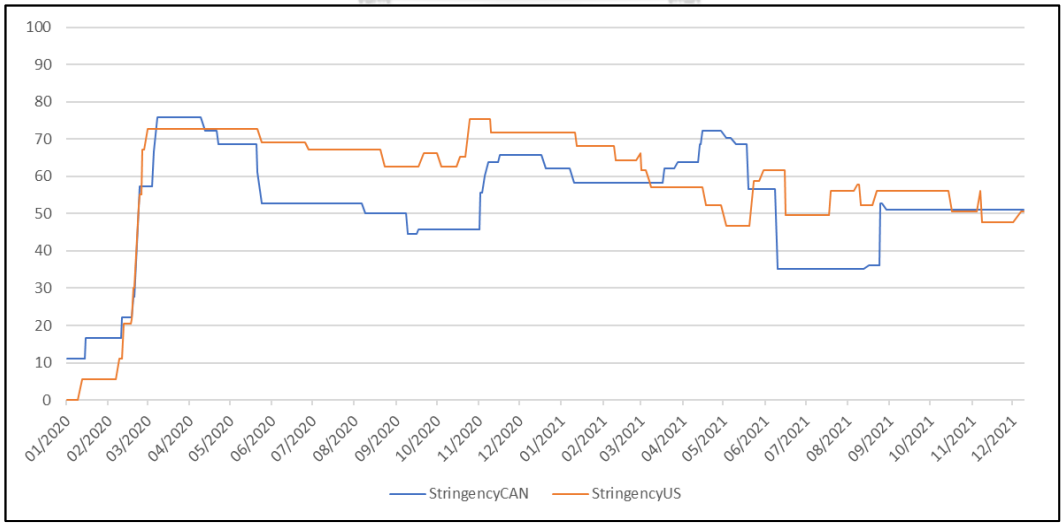


Figure 8: Stringency index of Canada and US

1 January 2021 – 31 December 2021



We decided to further examine the impact by implementing difference between COVID-19 cases growth of Canada relative to US and difference between stringency index of Canada relative to US instead of using separate variables for each country so that we can clearly see the impact when the difference (Canada relative to US) between countries is higher/lower.

$CaseGRDiff_{t-1}$ is the difference in percentage point between 1-day-lagged growth of COVID-19 cases of Canada relative to US and $StringencyDiff_t$ is the difference between stringency index of Canada relative to US, calculated using below formulas.

$$CaseGRDiff_{t-1} = CaseGRCAN_{t-1} - CaseGRUS_{t-1}$$

$$StringencyDiff_t = StringencyCAN_t - StringencyUS_t$$

After replacing the difference variables to the original model of hypothesis 2, our new model is as below.

$$\begin{aligned} Premium_{i,t} = {} & \alpha + \beta_1(CaseGRDiff_{t-1}) + \beta_2(StringencyDiff_t) \\ & + \beta_3(CaseGRDiff_{t-1}) * (StringencyDiff_t) + \beta_4\left(LiquidityCAN_{i,t}\right) \\ & + \beta_5\left(LiquidityUS_{i,t}\right) + \beta_6\left(RiskCAN_{i,t}\right) + \beta_7\left(RiskUS_{i,t}\right) \\ & + \beta_8 ln\left(MktCap_{i,t}\right) + \beta_9\left(Premium_{i,t-1}\right) + \beta_{10}(ExchangeRate_t) \\ & + \beta_{11}(InterestCAN_t) + \beta_{12}(InterestUS_t) + u_t \end{aligned}$$

As we use difference from value of Canada (home country) minus value of US (foreign country), we expected the increase of the difference in growth of COVID-19 cases of Canada relative to US to have negative impact to the price premium (the

higher the growth of COVID-19 cases of Canada over the growth of COVID-19 cases of US, the lower the price premium). On the contrary, we expected the increase of difference in stringency index of Canada relative to US to have positive impact to the price premium (the higher the stringency index of Canada over the stringency index of US, the higher the price premium)

The results from modified model of our hypothesis 2 (using variables of difference between Canada and US instead of separate variables for each country) are presented in Table 5, column (3) and (4).

Column (3) shows regression results of our hypothesis 2 when implemented difference in growth of COVID-19 cases of Canada relative to US as one variable and implemented difference in stringency index of Canada relative US as one variable instead of separate variables for each country and using pre-winsorzied data. Aligned with our expectation, the results from the regression suggest that higher difference in growth of COVID-19 cases of Canada relative to US has significant negative impact to the price premium of TSX shares relative to US shares. On the other hand, higher difference in government response to COVID-19, or stringency index, of Canada relative to US is positively and significantly related to the price premium of TSX shares relative to US shares.

As for regression results for the expected negative impact from interaction term between difference in growth of COVID-19 cases of Canada relative to US and government response to COVID-19 of Canada relative to US, it was found to be insignificant i.e. there is no statistical evidence to support that there is negative impact from the variable to price premium of TSX shares relative to US shares.

Column (4) shows regression results from using variables of difference between countries and using winsorized data. The results of the difference in growth of COVID-19 cases, difference in stringency index and the interaction term when using pre-winsorized data and winsorized data are aligned with each other, as shown in Column (3) and Column (4), respectively.

Table 5: Regression results – Hypothesis 2 – Impact from growth of COVID-19 cases and stringency index of Canada and US to price premium of TSX shares relative to US shares

VARIABLES	(1) Using separate variables for Canada and US Before winsorization	(2) Using separate variables for Canada and US After winsorization	(3) Using variables of difference between Canada and US Before winsorization	(4) Using variables of difference between Canada and US After winsorization
$CaseGRCAN_{t-1}$	0.0616	0.0300		
	(0.0297)	(0.0278)		
$StringencyCAN_t$	0.000135**	3.80e-05		
	(6.89e-05)	(5.96e-05)		
$CaseGRCAN_{t-1}$*$StringencyCAN_t$	-0.00324***	-0.00276		
	(0.00160)	(0.00175)		
$CaseGRUS_{t-1}$	0.0223	-0.0634		
	(0.0338)	(0.0272)		
$StringencyUS_t$	5.63e-05	-6.13e-05*		
	(4.55e-05)	(3.20e-05)		
$CaseGRUS_{t-1}$*$StringencyUS_t$	0.000347	0.00381**		
	(0.00152)	(0.00158)		
$CaseGRDiff_{t-1}$			-0.0667*	-0.0479*
			(0.0445)	(0.0315)
$StringencyDiff_t$			2.10e-05*	1.76e-05*
			(1.43e-05)	(1.29e-05)
$CaseGRDiff_{t-1}$*$StringencyDiff_t$			0.00797	0.00572
			(0.00524)	(0.00371)
$RiskCAN_{i,t}$	0.0324	0.0275	0.0214	0.0349
	(0.0333)	(0.0373)	(0.0335)	(0.0368)
$RiskUS_{i,t}$	0.0249	0.00776	0.0154	0.0137
	(0.0278)	(0.0230)	(0.0220)	(0.0239)
$LiquidityCAN_{i,t}$	0.0544	0.0952	0.0601	0.0928
	(0.0808)	(0.103)	(0.0790)	(0.102)
$LiquidityUS_{i,t}$	-0.000872	0.000481	-0.000487	-0.00120
	(0.000652)	(0.00450)	(0.000422)	(0.00383)
$\ln(MktCap_{i,t})$	0.00151	0.00143	0.00142	0.00149
	(0.00125)	(0.00134)	(0.00127)	(0.00132)
$ExchangeRate_t$	0.00795	-0.0372***	-0.0170**	-0.0162***
	(0.0214)	(0.0144)	(0.00681)	(0.00619)
$InterestCAN_t$	0.261	-3.286***	-2.330*	-1.764**
	(1.458)	(1.196)	(1.275)	(0.848)
$InterestUS_t$	0.0556	3.783***	2.379*	1.811**
	(1.566)	(1.320)	(1.224)	(0.801)
$Premium_{i,t-1}$	0.115***	0.0954***	0.106***	0.102***
	(0.0432)	(0.0313)	(0.0396)	(0.0308)
Constant	-0.0367	0.0356	0.00836	0.00592
	(0.0324)	(0.0257)	(0.0101)	(0.00929)

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

HYPOTHESIS 3

Table 6 presents results based on models of hypothesis 3, using fixed-effect estimator.

H3.1 Increase of COVID-19 cases in Canada is positively related to volatility of price premium of TSX shares relative to US shares.

H3.2 Increase of COVID-19 cases in US is positively related to volatility of price premium of TSX shares relative to US shares.

H3.3 Government response to COVID-19 in Canada is positively related to volatility of price premium of TSX shares relative to US shares.

H3.4 Government response to COVID-19 in US is positively related to volatility of price premium of TSX shares relative to US shares.

Column (1) shows regression results of our hypothesis 3 from using pre-winsorized data. As per the results, growth of COVID-19 cases in US and stringency index of both Canada and US were found to be in positive sign. The results suggest that there is significant positive impact from the variables to volatility of price premium of TSX shares relative to US shares i.e. they lead to higher volatility of the price premium. This is aligned with our expectation and also supports results from other existing literatures which studying impact of the COVID-19 cases and government response to COVID-19 to stock price volatility in each country (Albulescu 2020; Baig, Butt, Haroon and Rizvi 2021; Caporale, Kang, Spagnolo and Spagnolo 2021; Engelhardt, Krause, Neukirchen and Posch 2021).

As for growth of COVID-19 cases in Canada, as per the result, we failed to reject null hypothesis of our hypothesis 3.1, meaning that there is no statistical evidence to support that there is positive impact from the variable to volatility of the price premium. Our result is not aligned with the existing literatures mentioned previously in this case. However, the result is aligned with result from Sergi, Harjoto, Rossi and Robert (2021) which also studied the impact of COVID-19 cases to stock price volatility and found no significant positive impact from the COVID-19 cases.

Column (2) show regression results of our hypothesis 3 from using pre-winsorized data. The interaction term between COVID-19 cases growth and government response of both Canada and US which are expected to have positive impact were found to be significantly and positively related to volatility of price premium of TSX shares relative to US shares.

The results we got from pre-winsorized data as shown in Column (1) and winsorized data as shown in Column (2) for our main independent variables and interaction terms are not much different. There are some differences in values of coefficients and significance level, but the observed significant positive/negative or insignificant impact from our main independent variables and the interaction term to volatility of the price premium are aligned.

Table 6: Regression results – Hypothesis 3 – Impact from growth of COVID-19 cases and stringency index of Canada and US to volatility of price premium of TSX shares relative to US shares

VARIABLES	(1) Before winsorization	(2) After winsorization
$CaseGRCAN_{t-1}$	-0.000704	-0.00110
	(0.000507)	(0.000434)
$StringencyCAN_t$	4.45e-05***	4.56e-05***
	(3.13e-06)	(2.68e-06)
$CaseGRCAN_{t-1}$*$StringencyCAN_t$	0.000135***	0.000130***
	(2.17e-05)	(1.86e-05)
$CaseGRUS_{t-1}$	0.000302**	0.000393***
	(0.000151)	(0.000129)
$StringencyUS_t$	9.69e-05***	9.24e-05***
	(3.62e-06)	(3.10e-06)
$CaseGRUS_{t-1}$*$StringencyUS_t$	3.52e-05***	2.43e-05**
	(1.37e-05)	(1.17e-05)
$LiquidityCAN_{i,t}$	-0.0723***	-0.0670***
	(0.00704)	(0.00794)
$LiquidityUS_{i,t}$	-0.00174***	-0.0136***
	(0.000369)	(0.00105)
$\ln(MktCap_{i,t})$	-0.00327***	-0.00319***
	(6.06e-05)	(5.21e-05)
$Premium_{i,t}$	-0.0353***	-0.0448***
	(0.00225)	(0.00223)
$InterestCAN_t$	1.608***	1.395***
	(0.0494)	(0.0424)
$InterestUS_t$	-1.106***	-0.904***
	(0.0490)	(0.0420)
Constant	0.0224***	0.0222***
	(0.000545)	(0.000468)
Firm FE	YES	YES
R-squared	0.316	0.363
Adjusted R-squared	0.316	0.363

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Conclusions

In this research, evidence from 164 Canadian companies listed in Toronto Stock Exchange (TSX shares) and cross-listed in New York Stock Exchange or NASDAQ (US shares), we conducted regression to examine impact from growth of COVID-19 cases and government response to COVID-19 (using stringency index as a proxy) to stock return of the cross-listed companies in each country (home country and foreign country), to mispricing in the cross-listed companies and to volatility of the mispricing, using price premium of TSX shares (home country) relative to US shares (foreign country) as a proxy for the mispricing.

Our findings show evidence that growth of COVID-19 cases in Canada and US are negatively related to stock return and government response to COVID-19 is positively related to stock return in each country. However, for case of Canada, the positive impact from government response to COVID-19 can only be observed via interaction term between growth of COVID-19 and government response to COVID-19.

Examining impact of COVID-19 cases growth and government response to price premium of TSX shares relative to US shares, we found that when using growth of COVID-19 cases and government response to COVID-19 in each country as separate variables, our results suggest that only government response to COVID-19 in Canada was found to have significant positive impact to the price premium while there is no statistical evidence to support other related hypothesis.

In this research, we also further examined the impact by using difference in growth of COVID-19 cases of Canada (home country) relative to US (foreign

country) as one variable and difference in stringency index of Canada (home country) relative to US (foreign country) as one variable, instead of separate variables for each country, to investigate the impact and our results show statistical evidence to support that the difference in growth of COVID-19 cases of Canada relative to US has significant negative impact to the price premium. On the other hand, difference in government response to COVID-19 of Canada relative to US has significant positive impact to the price premium. Both of them are aligned with our expectation on the impact of the difference in COVID-19 cases growth and government response to COVID-19 between home country and foreign country to price premium of cross-listed companies.

We have also examined impact of the variables to volatility of the price premium and our findings suggest that growth of COVID-19 cases and government response to COVID-19 were found to have significant positive impact to volatility of the price premium i.e. cause increase in the volatility. Only COVID-19 cases growth in Canada which the positive effect can only be observed via interaction term.

The result from this research can be beneficial to arbitrageurs and investors in the markets as it investigated mispricing in cross-listed companies (price difference and volatility), which may lead to arbitrage opportunity. Moreover, as most of the existing literatures related to impact of COVID-19 to stock markets focus their study on the impact to specific country and almost none that study on the impact to cross-listed companies, this study will be a complement to the existing literatures studying impact of COVID19 or global crisis to stock markets and also to the existing literatures studying mispricing of cross-listed companies.

REFERENCES

Aharon, David Y., Ahmed S. Baig, and R. Jared DeLisle, 2021. The impact of government interventions on cross-listed securities: Evidence from the COVID-19 pandemic, *Finance Research Letters. 102276.*

Al-Awadhi, M. Abdullah, Khaled Alsaifi, Ahmad Al-Awadhi, and Salah Alhammadi, 2020. Death and contagious infectious diseases: Impact of the COVID-19 virus on stock market returns, *Journal of Behavioral and Experimental Finance 27 (2020) 100326*.

Albaity, Mohamed Shikh, 2011. Impact of the Monetary Policy Instruments on Islamic Stock Market Index Return, *Economics Discussion Paper No. 2011-26.*

Albulescu, Claudiu Tiberiu, 2020. COVID-19 and the United States financial markets' volatility, *Finance Research Letters 38 (2021) 10169*.

Ashraf, Badar Nadeem, 2020a. Economic impact of government interventions during the COVID-19 pandemic: International evidence from financial markets, *Journal of Behavioral and Experimental Finance 27 (2020) 100371*.

Ashraf, Badar Nadeem, 2020b. Stock markets' reaction to COVID-19: Cases or fatalities?, *Research in International Business and Finance 54 (2020) 101249*.

Baig, Ahmed S., Hassan Anjum Butt, Omair Haroon, and Syed Aun R. Rizvi, 2021. Deaths, panic, lockdowns and US equity markets: The case of COVID-19 pandemic, *Finance Research Letters 38 (2021) 101701*.

Bailey, Warren, and Julapa Jagtiani, 1994. Foreign ownership restrictions and stock prices in the Thai capital market, *Journal of Financial Economics 36 (1994) 57-87*.

Beckmann, Klaus S., Thanh Ngo, and Daphne Wang, 2015. The informational content of ADR mispricing, *J. of Multi. Fin. Manag. 32-33 (2015) 1–14.*

Bissoon, Raksha, Boopen Seetanah, Reena Bhattu-Babajee, Narvada Gopy-Ramdhany, and Keshav Seetah, 2016. Monetary Policy Impact on Stock Return: Evidence from Growing Stock Markets, *Theoretical Economics Letters, 2016, 6, 1186-1195*.

Capelle-Blancard, Gunther, and Adrien Desroziers, 2020. The stock market is not the economy? Insights from the COVID-19 crisis, *Covid Economics (28), 29-69.*

Caporale, Guglielmo Maria, Woo-Young Kang, Fabio Spagnolo, and Nicola Spagnolo, 2021. The Covid-19 Pandemic, Policy Responses and Stock Markets in the G20, *CESifo Working Paper No. 9299*.

Chan, Justin S.P., Dong Hong, and Marti G. Subrahmanyam, 2008. A tale of two prices: Liquidity and asset prices in multiple markets, *Journal of Banking & Finance 32 (2008) 947–960*.

Chan, Kalok, and Johnny K.H. Kwok, 2005. Market Segmentation and Share Price Premium: Evidence from Chinese Stock Markets, *Journal of Emerging Market Finance, 4:1 (2005)*.

Chang, Chun-Ping, Gen-Fu Feng, and Mingbo Zheng, 2021. Government Fighting Pandemic, Stock Market Return, and COVID-19 Virus Outbreak, *Emerging Markets Finance and Trade, 57:8, 2389-2406.*

Chebbi, Kaouther, Mohammed Abdullah Ammer, and Affan Hameed, 2021. The COVID-19 pandemic and stock liquidity: Evidence from S&P 500, *The Quarterly Review of Economics and Finance 81 (2021) 134–142*.

Domowitz, Ian, Jack Glen, and Ananth Madhavan, 1997. Market Segmentation and Stock Prices: Evidence from an Emerging Market, *Journal of Finance, 1997, vol. 52, issue 3, 1059-85*.

Engelhardt, Nils, Miguel Krause, Daniel Neukirchen, and Peter N. Posch, 2021. Trust and stock market volatility during the COVID-19 crisis, *Finance Research Letters 38 (2021) 101873*.

Erdem, Orhan, 2020. Freedom and stock market performance during Covid-19 outbreak, *Finance Research Letters 36 (2020) 101671*.

Harjoto, Maretno Agus, Fabrizio Rossi, Robert Lee, and Bruno S. Sergi, 2020. How do equity markets react to COVID-19? Evidence from emerging and developed countries, *Journal of Economics and Business 115 (2021) 105966*.

Haroon, Omair, and Syed Aun R. Rizvi, 2020. Flatten the Curve and Stock Market Liquidity – An Inquiry into Emerging Economies, *Emerging Markets Finance and Trade, 56:10.*

Hatmanu, Mariana, and Cristina Cautisanu, 2021. The Impact of COVID-19 Pandemic on Stock Market: Evidence from Romania, *Int. J. Environ. Res. Public Health 2021, 18, 9315.*

Huang, Shoujun, and Hezhe Liu, 2021. Impact of COVID-19 on stock price crash risk: Evidence from Chinese energy firms, *Energy Economics 101 (2021) 105431.*

Ioannidis, Christos, and Alexandros Kontonikas, 2007. The impact of monetary policy on stock prices, *Journal of Policy Modeling 30 (2008) 33–53.*

Karolyi, G. Andrew, Lianfa Li, and Rose Liao, 2009. A (partial) resolution of the Chinese discount puzzle, *Journal of Financial Economic Policy, Vol. 1 No. 1, 2009, pp. 80-106.*

Li, Yuan, and Jimmy Ran, 2020. Investor Sentiment and Stock Price Premium Validation with Siamese Twins from China, *J. of Multi. Fin. Manag. 57–58 (2020) 100655*.

Liu, Jun, Kai Wu, Fuwei Jiang, and Botao Fan, 2021. Market Liquidity and Price Disparity: Evidence from Chinese Cross-Listed Firms, *ERN: Other Econometric Modeling: Capital Markets - Asset Pricing (Topic).*

Scherf, Matthias, Xenia Matschke, and Marc Oliver Rieger, 2021. Stock market reactions to COVID-19 lockdown: A global analysis, *Finance Research Letters, 102245. .*

Sergi, Bruno S, Maretno Agus Harjoto, Fabrizio Rossi, and Lee Robert, 2021. Do stock markets love misery? Evidence from the COVID-19, *Finance Research Letters 42 (2021) 101923*.

Tran, Phan Huy Hieu, and Thu Ha Tran, 2021. Stock markets' reaction to Covid-19: The joint impact of uncertainty avoidance culture and government response - Evidence from emerging countries, *Review of Behavioral Finance.*

Wu, Qinqin, Ying Hao, and Jing Lu, 2017. Investor sentiment, idiosyncratic risk, and mispricing of American Depository Receipt, *J. Int. Financ. Markets Inst. Money 51 (2017) 1–14*.

Xie, Lijuan, Mei Wang, and Toan Luu Duc Huynh, 2021. Trust and the stock market reaction to lockdown and reopening announcements: A cross-country evidence, *Finance Research Letters, 102361. .*

Xu, Dinghai, 2022. Canadian stock market volatility under COVID-19, *International Review of Economics and Finance 77 (2022) 159–169.*

Yang, Haochang, and Peidong Deng, 2021. The Impact of COVID-19 and Government Intervention on Stock Markets, *Asian Economics Letters., 1(4).*

Yousef, Ibrahim, 2020. Spillover of COVID-19: Impact on Stock Market Volatility, *International Journal of Psychosocial Rehabilitation, Vol. 24, Issue 06 (2020) 18069-18081.*

VITA

NAME	Chomtarn Junanukul
DATE OF BIRTH	24 June 1994
PLACE OF BIRTH	Thailand
INSTITUTIONS ATTENDED	Thammasat University, Bachelor of Accountancy, 2016
HOME ADDRESS	99/301 Soi Ladprao 41, Jankasem, Jatujak, Bangkok 10900