EXAMINING ARBITRAGE OPPORTUNITIES AMONG CANADIAN CROSS-LISTED SECURITIES: EVIDENCE FROM STOCK AND OPTION MARKETS

A Thesis Submitted to

The College of Graduate Studies and Research

In Partial Fulfillment of the Requirements

For the Degree of Master of Science in Finance

In the Department of Finance and Management Science

University of Saskatchewan

Saskatoon, Saskatchewan

By

Zhen Li

PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a Degree of Master of Science in Finance from the University of Saskatchewan, I agree that the Libraries of the University of Saskatchewan may make it freely available for inspection. I further agree that permission for copying this thesis in any manner, in whole or in part, for scholarly purposes may be granted by the professor or professors who supervised my thesis work or, in their absence, by the Head of the Department or the Dean of the College in which my thesis was done. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of Saskatchewan in any scholarly use which may be made of any material in my thesis.

Requests for permission to copy or make other use of materials in this thesis in whole or in part should be addressed to:

Head of the Department of Finance and Management Science

Edwards School of Business

University of Saskatchewan

Saskatoon, Saskatchewan

S7N 5A7

ABSTRACT

A cross-border listing occurs when an individual company establishes a secondary listing on a stock exchange abroad. In this paper, we analyze and compare the arbitrage proportions (through violation of put-call parity) of publicly traded cross-listed Canadian stocks, and those of industry and performance matched US domestically-listed shares. The cross-listed Canadian stocks are listed on both of the Toronto Stock Exchange (TSX) and either the New York Stock Exchange (NYSE) or the American Stock Exchange (AMEX).

Arbitrage opportunities exist when put-call parity is violated. Our empirical results show that in most circumstances, both domestic put-call parity and cross-border put-call parity hold well in the two countries. However, in Canadian market, a high proportion of arbitrage opportunities could be detected in closing prices on the particular date of March 14, 2007.

On March 14th 2007, many of the observations in the Canadian market contained arbitrage opportunities. Both domestic and cross-border put-call parity was violated. However, we fail to find the same phenomenon in the US market. In the US market, opportunities for arbitrage occur rarely and sporadically. We also find that the option trading volume in the Canadian market is lower than that in the US market, and during dramatic market price drops, the option trading volume remains at a low level.

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to my thesis supervisor, Dr. Craig Wilson for his guidance, support, and encouragement. His sound advice and direction were imperative to the creation of this thesis. I would like to acknowledge the help of my committee members: Dr. Marie Racine and Dr. Zhenyu Wu, as well as Dr. Mobinul Huq, the external examiner. Without their comments and suggestions, I would not been able to complete my thesis. I would also like to thank Dr. Zhao Sun. In addition, I also thank College of Graduate Studies & Research for providing me a University Graduate Scholarship. Lastly, I would like to acknowledge all of the faculty and staff of the Department of Finance and Management Science for their teaching and assistance during my studies at the University.

TABLE OF CONTENTS

PERMISSION TO USE I

ABSTRACT II

ACKNOWLEDGEMENTS III

LIST OF TABLES VI

LIST OF FIGURES VII

LIST OF SYMBOLS VIII

1 INTRODUCTION 1

2 LITERATURE REVIEW 4

2.1 Arbitrage 4

2.2 Cross-listed stocks 5

2.3 Put-call parity 7

3 HYPOTHESES 10

3.1 Effects of Cross-listing on arbitrage opportunities 10

3.2 A dominant-satellite relationship between Canadian and US markets 12

4 DATA 15

4.1 Cross-listed US and Canadian securities 15

4.2 The US securities only listed and traded in domestic market (Purely US Sample) 17

5 METHODOLOGIES 19

6 RESULTS & ANALYSES 22

6. 1 Arbitrage existing in the cross-listed Canadian sample 22

6. 2 Arbitrage opportunities existing in the cross-listed US sample 23

6. 3 Arbitrage opportunities existing in the purely US sample 23

7 ROBUSTNESS CHECK 25

7.1 Robustness of arbitrage opportunities 25

7.2 Robustness check by adopting full sample 31

8 CONCLUSIONS & LIMITATIONS 33

REFERENCES **36**

APPENDIX **42**

LIST OF TABLES

Table 1: 29 firms composed of cross-border samples 42

Table 2: The control purely US sample matched by industry and Tobin's q 43

Table 3: Summary statistics for option pairs in three samples 45

Table 4: Arbitrage existing in cross-listed Canadian sample generated from violations of put-call parity 46

Table 5: Arbitrage existing in cross-listed US sample generated from violations of put-call parity 48

Table 6: Arbitrage existing in pure US sample generated from violations of domestic put-call parity 50

Table 7: Arbitrage opportunities sorted by date 51

Table 8: Intra-day price drops of some Canadian leading companies on March 13th, 2007 53

Table 9: Price changes and co-movement on March 14th, 2007 in both the Canadian and the US markets 54

Table 10: One sided-test: Paired trading volume for options for means 55

Table 11: One-sided test: Comparison between option trading volume in dramatic market price drops and normal monthly average 56

Table 12: Summary statistics for option pairs in three samples (Full sample) 57

Table 13: Arbitrage existing in cross-listed Canadian sample generated from violations of put-call parity (Full sample) 57

Table 14: Arbitrage existing in cross-listed US sample generated from violations of put-call parity (Full sample) 60

Table 15: Arbitrage existing in pure US sample generated from violations of domestic put-call parity (Full sample) 62

Table 16: Arbitrage opportunities reported by date (Full sample) 63

LIST OF FIGURES

Figure 1: S&P 500 daily closing prices in 2007 66

Figure 2: Intraday price changes of S&P 500 and S&P/TSX in 2007 67

Figure 3: Price movements of the S&P/TSX composite index and the Dow Jones industrial average 68

Figure 4: Distribution of arbitrage reported on March 14th, 2007 70

Figure 5: Trading volume of options in the US and Canadian markets 71

Figure 6: Dramatic price drops in the Canadian market in 2007 73

Figure 7: The time line of the 10 biggest stock price drops in the Canadian market in 2007 74

Figure 8: The option trading volume in the 10 biggest market price drops 75

LIST OF SYMBOLS

C: the price for a call

$C(ask)$: ask price of a call option

$C(bid)$: bid price of a call option

div : all (assumed to be known with certainty) dividends payable prior to (or on) the common expiration time for the put and call

div^f : is the translated dividend amount collected from foreign country

P : the price for a put

$P(ask)$: ask price of a put option

$P(bid)$: bid price of a put option

PV [div]: the present value of all (assumed to be known with certainty) dividends payable prior to (or on) the common expiration time for the put and call

PV [div^f]: the present value of the translated dividend amount

S : the stock price

S_t: spot price of a stock

$S^f(bid)$: foreign bid price of the stock which is translated into local currency

K: strike price of an option

1 INTRODUCTION

As economic globalization increases, more and more corporations are establishing cross-listings on foreign stock exchanges. This increases firms' access to new equity capital, and existing cross-listed home-country public shares benefit from greater liquidity and pricing efficiency when firms inter-list in foreign stock exchanges, such as the US stock exchanges. Consolidation and competition with foreign markets lower the barriers to capital flows and make information release more efficient. Further domestic investors may take advantage of enhanced liquidity and favourable lower cost of domestic capital market, allowing them to enjoy higher valuations.

A cross-border listing (inter-listing, dual listing, or simply cross-listing) occurs when an individual company establishes a secondary listing on a stock exchange abroad. In this paper, we analyze and compare the proportions of arbitrage opportunities available to publicly traded inter-listed Canadian stocks, and those of industry and performance matched US domestically-listed shares. The cross-listed Canadian stocks are listed on both of the Toronto Stock Exchange (TSX) and either the New York Stock Exchange (NYSE) or the American Stock Exchange (AMEX).

There is a rich literature on the impact of cross-listings on stock price behaviour. However, to the best of our knowledge, there are only a few existing studies that attempt to examine how cross-listing behaviour influences option markets. By adopting put-call parity, we relate the stock prices to their corresponding options. The arbitrage opportunities we investigate in this paper are obtained from deviations of prices from their rational range implied by put-call parity.

In this paper, we examine the issue of whether cross-listings bring more arbitrage opportunities to market quotes. Segmentations between the US and Canada, including information release insufficiency, legal dissimilarities, and variation in transaction costs are likely to lead the multiple-market setting to contain more arbitrage opportunities. In other words, market prices of dual-listed stocks may lie beyond their rational range more frequently than the market quotes of an otherwise equivalent purely domestically-listed security. However, the em-

pirical evidence from arbitrage tests in this paper rejects this hypothesis, and suggests a high level of integration between the two countries.

Consequently, we test the "dominant-satellite" relationship between the US and Canadian markets in this paper. When information arrives, prices adjust based on expectations of investors and traders. Compared to the satellite market, the dominant market is more sensitive to the shocks, thus, price adjustment first takes place in the dominant market. In order to keep a long run integrated relationship, satellite price quotes adjust to their counterparts in the dominant market. Due to communication lags between the two countries, market quote violations may occur more frequently in the satellite market. Ordinarily, it is assumed that the home country is the dominant and the foreign country is the satellite. However in this case, since the US market is larger and more liquid, it's possible that these roles are reversed for Canadian cross-listed stocks. Furthermore, since the two countries are highly integrated in terms of access to information with primarily common time zones, neither market may dominate the other. Based on the empirical results of arbitrage proportions, it seems that put-call parity generally holds well in both Canadian and US markets. Therefore, it is difficult to determine which country is dominant using this criterion. Investigation into the ten largest stock price drops in the Canadian market in 2007 suggests that the Canadian quotes tend to follow the US quotes.

In addition, we check the robustness of our results. Slight differences in proportion of arbitrage opportunities are found between the cross-listed samples and a purely US control sample, and a puzzle we uncover is that most of the arbitrage opportunities among the Canadian quotes of the cross-listed stocks occur on one particular day, Mar 14, 2007. This was one day after a dramatic price drop (around 2%) in both Canadian and US stock markets. The dissimilarity of price movements of the two countries' markets after this market slump and the relatively low option trading volume in Canada may explain the temporary violations of put-call parity in the Canadian market in this extreme case.

The remainder of this paper is organized as follows: Chapter 2 outlines the motivation for the research and provides a useful theoretical backdrop for the various existing studies related to the topic. Chapter 3 develops the key hypotheses about arbitrage proportions of

cross-listings. Chapter 4 describes the data employed and the filter used in the study. The methodology used to test the hypotheses and explore the factors that influence arbitrage in cross-listings is presented in Chapter 5. Chapter 6 analyzes the empirical results. Robustness check of results is provided in Chapter 7, and the conclusions along with limitations of the study, follow in Chapter 8.

2 LITERATURE REVIEW

This chapter reviews the pertinent literature for this thesis. Section 1 presents the definition of arbitrage and how it applies to the special cases described in previous studies. Section 2 discusses the evolution and motivation behind cross-listings. The drawbacks of dual-listings will also be analyzed in this section. Furthermore, the feasibility of making comparisons between the US market and Canadian market will be discussed. Section 3 focuses on put-call parity and documents the literature about options and short-sell restrictions.

2.1 Arbitrage

Arbitrage is one of the most important concepts in finance theory, and most existing pricing theories and models are related to it. Rational pricing theory assumes that any deviation from arbitrage-free price levels for an asset results in the price difference being "arbitraged away," since an arbitrageur could profit from mispriced securities. A common textbook definition of arbitrage is as follows:

> "An arbitrage opportunity is a self-financing trading strategy that generates positive real wealth with no risk." (Jarrow, 1992).

In a multi-market situation, arbitrage is closely related to "the law of one price," which states that the same asset must trade at the same price on all markets. Violation of the law of one price leads to an arbitrage opportunity for traders who can participate in both markets. In this paper, we derive a rational range for each stock, based on put-call parity. If the market quote violates the corresponding range, an arbitrage opportunity may exist. Arbitrageurs earn risk-free profits by buying at a relatively low price and selling high.

Baker and Savasoglu (2002) investigated arbitrage in mergers and acquisitions, which consists of buying the stock of a takeover target company while shorting the shares of the acquiring company. Erickson et al. (2003) worked on municipal bond arbitrage and illustrated how tax factors play a crucial role in municipal bond arbitrages. In terms of convertible bond arbitrage, arbitrageurs have options to return the bond to the issuing company in exchange for shares of the company's stock.

Gagnon et al. (2004) studied multi-market trading and arbitrage existence. Dual-listed

companies provided the major multi-market situation in their paper. Arbitrage opportunities are established by taking a long position in the relatively underpriced part, and shorting the relatively overpriced part. Following the definition of arbitrage given by Jarrow (1992), we focus on arbitrage derived from violations of put-call parity for dual-listed Canadian stocks and domestic-listed US stocks.[1]

2.2 Cross-listed stocks

Since the 1970s, internationalization of markets has been increasing. Institutions and investors invest capital in foreign stock markets to diversify their portfolios, reduce risks, and gain higher risk-adjusted returns than with purely domestic portfolios. If the foreign and domestic markets are segmented, a diversification effect should result from an international listing, causing a decrease in the standard deviation of stock returns (Howe and Madura, 1990). Mittoo (1992a) pointed out that companies perceive enhanced marketability, increased exposure for their products, and growth of shareholder base as crucial benefits of cross-border listings. The author examined the stock return of the dual listed companies and the empirical results suggested that the advantages of cross-listings overwhelm the high cost of dual listings, such that the net outcome of inter-listings should be positive. A similar result was obtained by Foerster and Karolyi (1993). They focused on cross-listed international stocks in the US market, and suggested that newly listed firms have the opportunity to finance their funds from a larger and more liquid market, which influences the cost of capital to some extent. However, some authors have argued that the investment barriers between foreign and home markets for cross-listings, such as transaction costs, information costs, and government controls on foreign exchanges, lead to market segmentation.

Chowdhry and Nanda (1991) extended the law of one price to derivatives. They found that, if stocks or derivatives are dual-listed on several stock exchanges, the market quotes on them in multiple locations are not always identical, due to different transaction costs stemming from various markets. Black (1974) suggested that some type of risk premium should

[1] We use put-call parity, instead of the usual "law of one price" to identify arbitrage opportunities among cross-listed securities, because it allows us to investigate them separately in both domestic and international markets. This is critical for making inferences about issues such as the dominant-satellite relationship, which we discuss below.

be added to the expected return of inter-listed stocks to compensate for the costs attributable to the barriers previously mentioned. Errunza and Losq (1985) established a valuation model on multi-national assets, and their findings supported the notion that the world markets are semi-integrated, and the return of dual-listed stocks exceed the theoretical return obtained from the capital asset pricing model (CAPM).

Most of these studies focus on the US market because of its size and liquidity. Xu and Fung (2004) investigated source-based Japanese derivatives cross-listed in the US, and they showed that the US markets have a strong link with Japanese markets. In addition, cross-market information flows lead US exchanges to make a greater contribution to returns in Japan. Hasbrouck (1995) examined the price discovery of dual-listed stocks in US markets. US markets are very efficient in providing a common price (the equilibrium prices of stock exchanges) to domestic markets. Therefore, US markets may play an important role in international listing.

Conversely, previous studies about cross-listings show that firms will initially consider a similar market or one within its trading bloc when choosing a place of inter-listing. This was expressed in studies such as Harvey (1990) and Biddle and Saudagaran (1989). Biddle and Saudagaran (1989) suspected that the importance of financial disclosure levels in different countries would be a major factor in inter-listing decisions.

In this study, we choose Canada-US cross-listed firms for a number of reasons. Firstly, Canada is the largest trading partner for the US and they share many cultural and business activities as well as close geographic proximity. Second, the number of cross-listed Canadian firms in the US is large enough to provide a substantial and accessible sample for our research. According to the listing information provided by the NYSE, Canadian stocks represent the largest group of foreign stocks listed in the US exchange from a single country, Moreover, those inter-listed Canadian stocks trade actively in both the domestic and US markets, which provides an opportunity for analyses. The coincidence of trading hours between 9:30 a.m. to 4:00 p.m. Eastern Time makes it easier to conduct tests on observations occurring simultaneously on the two exchanges (Eun and Sabherwal, 2003). Lastly, unlike securities from most other countries that are usually listed as American depositary receipts

(ADRs), Canadian securities are listed as ordinary shares.

Additional advantages of Canadian ordinaries can be found in Pulatkonak (1999). First, the certificate traded in the US for a dual-listed Canadian stock is identical to the one traded in Canada. Second, cross-border ownership and trading in the two countries are legal. Third, converting U.S securities to Canadian ones are not charged "conversion fees." Moreover, dividends may be paid in either US or Canadian dollars, regardless of trade locations. These advantages lead to the prevalence of inter-listings between Canada and the US.

Another motive to examine Canada-US inter-listed stocks involves the degree of integration or segmentation derived from the existence of investment barriers between the two markets. The result is that the expected returns of securities in one market may be different from that of the other market. Most literature in the early 1980s reports evidence of segmentation between the two countries; however, recent studies show that US and Canadian financial markets are fundamentally integrated. For example, Foerster et al. (1993) paid attention to trading volume. Their basic idea is that if there are different costs of trading stocks in Canadian and US financial markets, cross-listing of a stock should lead to a boost in overall trading volume; their regression results support this. Moreover, Eun and Sabherwal (2003) examined prices on the US exchanges and TSX, and found that the prices are non-stationary with a unit root, but they are co-integrated.

2.3 Put-call parity

In this paper, we aim to test for arbitrage on inter-listed stocks. The basic methodology is based on put-call parity, which is one of the most important no-arbitrage relations between stocks and options:

$$C - P = S - PV[K]. \tag{2.3.1}$$

One assumption of put-call parity is that, investors can buy and short the underlying securities without limitation. In other words, if short-selling constraints exist, which makes it more difficult to take advantage of arbitrage opportunities involving over-priced shares, then this no-arbitrage relationship may collapse. Ofek et al. (2004) provided evidence of a robust relationship between violations of no arbitrage put-call parity and short-sale restrictions. Baruch et al. (2007) claimed that if a stock price is irrationally high, it is potentially difficult for ra-

tional investors to sell them short and bring the price back to its rational level, because those traders cannot borrow and short it at a reasonable cost. In addition, even if investors find shares to sell short, the risk that the shorted shares may be recalled before the anticipated market correction or liquidation date may still limit arbitrage (Battalio and Schultz, 2006). Short selling restrictions would create the inequality constraint

$$C - P + \mathrm{PV}[K] \leq S, \tag{2.3.2}$$

which suggests violations of put-call parity should be more prevalent in only one direction. However, these violations are rare in our sample, and there is no significant evidence to show that they occur more frequently than the opposite violations.

With the development of derivatives, stock options are viewed as a highly useful and valuable market communications medium. Spais (2002) argued that stock options add value in business markets. Detemple and Selden (1991) demonstrated the option and the stock markets interact in general. Chakravarty et al. (2004) supported this argument by using the joint time series of stock prices and option-implied stock prices and found that price discovery occurs in both the stock and option markets. There is an extensive and growing literature that explores the links between short sales and option markets. Danielsen and Sorescu (2001) suggested that option introduction contributes to the mitigation of effects developed from short-sale constraints. According to Ofek et al. (2004), a synthetic short-sale stems from the portfolio formed by buying a call, writing an equivalent put, and taking a long position of a bond. Mayhew and Mihov (2004) found that options play a crucial role in eliminating the disadvantages of short-sale constraints, as they said:

> "Option markets facilitate short selling by allowing the lowest-cost trader to establish the short position in the underlying market. The introduction of traded options represents an economically important relaxation of short-sale constraints. There are several documented ways by which option markets lower the costs of short selling: First, they permit traders to take leveraged short positions without having to find a certain lender for the stock, post a large margin and trade under the 'uptick

rule'."

Generally, investors can take synthetic short positions in option markets to dispose of short-sale constraints. Empirical evidence found in Battalio et al. (2006) illustrates the advantages of synthetic shorts. As the expected proceeds from a synthetic short created from options and the expected proceeds from an actual short sale are almost the same, even hard-to-borrow stocks can be easily sold short synthetically, provided they have relatively liquid options trading on them. Moreover, synthetic shorts also have advantages that may offset their small additional costs to some extent such as the elimination of investors' "recall risk."

3 HYPOTHESES

The internationalization of stock markets allowed companies that formerly raised capital only in domestic markets to tap foreign sources by listing their stocks on foreign exchanges. An increasing number of firms, driven by marketing and financing advantages, in both developed and developing countries are affected by this trend, including many Canadian corporations, especially resource-based companies.

This chapter is designed to describe the hypotheses regarding the comparison between the domestically-listed and the cross-listed samples, and within the cross-listed samples. Section 1 outlines how arbitrage opportunities are expected to differ between inter-listing samples and the purely US sample, while Section 2 discusses the dominant-satellite relationship and how arbitrage opportunities differ between the Canadian and US samples.

3.1 Effects of Cross-listing on arbitrage opportunities

A complex trading structure develops for cross-listed firms. Licht (2006) pointed out that when a stock trades on more than one market, investors still stand ready to close any gap that develops between pieces of the same security in each market to seek arbitrages. According to the law of one price, such arbitrage opportunities will soon disappear and only one price will prevail for each stock. Arbitrageurs profit by buying underpriced securities and selling overpriced securities. Employing a CAPM framework, Jorion and Schwartz (1986) analyze integration and segmentation in the Canadian and the US stock market. With perfect integration, priced risk should be the systematic risk relative to the world market. As for complete segmentation, the only priced risk should be the domestic systematic risk. Failing to find either of these, the authors report partial segmentation in the two countries. Knez and Chen (1995) claim that the extent to which any two markets are segmented could be measured by the extent to which the law of one price is violated. If markets are partially or mildly integrated, in terms of cross-listings, profits are generated from executing cross-border transactions at lower cost, that is, arbitrageurs gain from purchasing stocks that yield higher return for comparable levels of risk. For market integration and segmentation, the question arises: do cross-listed stocks contain more arbitrage, compared with purely-domestic listed stocks? Canadian cross-listed stocks are ideal to test this question.

Jorion et al. (1986) find segmentation between markets, reject integration in the US and Canada, and explain it through legal barriers. These legal barriers include securities regulation and corporation governance regimes. Different countries provide a variety of business laws to warrant an efficient social order for production and investment. These laws not only affect publicly traded corporations but also investors. The Efficient Capital Market Hypothesis indicates that the impact these laws have on corporations and investors will immediately be impounded in market quotes. Cross-listing leads to a more complex trading structure and may be influenced by more laws and constraints. For example, when a recently enacted law in one country benefits investors, but its counterpart law in the other country harms investors, arbitrage may exist. However, this arbitrage opportunity could only exist theoretically since if investors could trade on it, it would disappear quickly.

Besides legal barriers, other factors that may also influence the existence of arbitrage opportunities in cross-listed stocks, such as corporate disclosure, are considered in this paper. Through inter-listing, a company subjects itself to more than one information disclosure regime, which may make information release more efficient. As a result, the market quotes reflect more material information, and arbitrage opportunities are reduced. To sum up, with cross-listing, the influence of corporate disclosure will likely decrease the number of arbitrages of domestic firms.

In reality, legal barriers and corporate disclosure may both impact stock prices. They move the likelihood of arbitrage opportunities in opposite directions. If the impact of legal barriers overwhelms the impact of corporate disclosure, arbitrages in multiple listings should be more likely than that of purely-domestic listings, and vice versa. We address this as an empirical question. In our paper, cross-border violations of put-call parity such as buying a stock in the US and selling the equivalent synthetic stock in Canada, or buying an actual share in Canada and synthetic shorting in the US are also examined. Cross-border ownership and trading in the two countries are legal and stocks denominated in US dollars could be converted to Canadian shares without conversion fees. In this case, cross-border trading may lead to fewer violations of put-call parity. Our first hypothesis is listed below.

Hypothesis 1: There is no significant difference between the arbitrage opportunities con-

tained in cross-listed stocks and those of purely domestically listed US stocks.

If we fail to reject Hypothesis 1, (i.e. if the null hypothesis that cross-listed stocks contain more arbitrage opportunities than purely US stocks is rejected), then, as we find, it suggests that legal barriers effects are overwhelmed by the disclosure benefits. This is discussed further in the next section.

3.2 A dominant-satellite relationship between Canadian and US markets

Although Canada and the US are similar in culture and economies, market informational segmentation still exists between them because of certain barriers, such as regulatory constraints, technological constraints and costs, corporate internal firewalls, etc.

Carbade and Silber (1979) found that prices of dual-listed securities in one market may follow earlier prices in the other market only partially, with some variance due to the specific trading environments. In this case, the price behaviour of one market may not be a perfect copy of its counterpart in the other country. Chowdhry and Nanda (1991) examined the differences of price discovery of multinational stocks and reached a similar conclusion. It was echoed by Nuemark et al. (1991) when they investigated price volatility. The possible reasons expressed by these authors are: legal regime effects, impact from informed traders who actively seek arbitrage opportunities in a dual-market setting, and information release concerns. For a cross-listed security, the impacts from one country may be different from the counterpart, thus each market may have a unique influence on price.

Because of informational impact, the domestic market of an inter-listed stock is more likely to be treated as the dominant market. Usually, the company's headquarter, where most important decisions and policies are made, is located in its home country. In addition, the majority of its shareholders and management are based in the home country, and it is possible to make corporate disclosure more efficiently in the domestic market. Prices in the foreign market adjust to the prices in domestic market, possibly with a time lag due to the speed of communications. In this case, the home market (the Canadian market in our paper) is expected to have more impact on price behaviour, so the domestic market should be treated as the dominant market. Early empirical evidence from other countries provides support for this argument. In empirical research of Israeli stocks cross-listed on the US over-the-counter

(OTC) market, Ben-Zion and Lieberman (1996), show that the Israeli market works as the leading market, and the US market acts as a satellite. Hauser et al. (1998) concluded that the domestic market in their paper, the Tel Aviv Stock Exchange (TASE) contributed more to price behaviour than the NYSE. Liberman et al. (1996) employed an error correction model and examined trading volume of the two markets when they tested the dominant-satellite relationship. Their findings provided strong evidence of US price reaction to TASE. Grammig et al. (2001) investigated price discovery in German stocks multiple-listed in the US, and discovered that more than 80% of price discovery occurred domestically. Scholars believed that the impact of terrorism and unexpected inflation in Israel could help to explain why Israeli market acted as the dominant market.

Prior literature about the dominate-satellite relationship for cross-listed Canadian firms is mixed. Compared to the Canadian market, the US financial market is more liquid, and investors prefer to trade on more liquid markets, so managers can decrease the company's cost of capital by increasing the liquidity of their stock. Foerster and Karolyi (1993) examined bid-ask spreads, and found that overall trading costs of Canadian stocks have significantly decreased after cross-listing. They also pointed out that the transaction costs decrease as a result of the large proportion of transactions being made in the US market. Market makers in Canada tend to lower transaction costs to attract investors, and compete with the US market. Taking advantages of lower cost of capital and large trading volume, the US market seems to operate as the dominant market.

By investigating the feedback on stock prices of inter-listed companies, a body of research supports the claim that in most cases, the US market is the price discovery mechanism for cross-listed non-US stocks. Based on the concept of partial market integration, price adjustments take place in both markets. This kind of adjustment may be two-sided, so prices in the satellite market may move toward earlier prices in the dominant market, while new information reflected by prices in the satellite market can also influence prices in the dominant market. The market with the heavier weight on price influence is considered to be the dominant market. Hasbrouck (1995) found that the US market influences the stock price behaviour of dual-listed stocks more than the home market. Pascual et al. (2006) found that the US

market had a strong and continuing influence on the prices of inter-listed Spanish stocks.

According to the empirical results of Chen et al. (2002), stock quotes obtained from one market adjust to price changes in the other market, in order to maintain a long-run cointegrated relationship. However, perfect cointegration between two countries is seldom established in reality because of market frictions and market inefficiency. Small price disparities due to slow adjustment occur in co-integrated markets making arbitrage opportunities available. The core concept of the dominant-satellite relationship is that the market quotes of the satellite market react more to their counterparts in the dominant market. Thus, we are more likely to find arbitrage in the satellite market. In this paper, we attempt to examine the dominant-satellite relationship by comparing the arbitrage proportions of both US and Canadian quotes of cross-listed Canadian securities.

Hypothesis 2: In terms of cross-listed securities, arbitrage proportions reported in Canadian markets are not significantly different from those existing in US markets.

If we fail to reject Hypothesis 2, then statistic results show that the arbitrage proportions of both US and Canadian quotes are not significantly different from each other. Thus the claim that the home market (Canadian market in this paper) always acts as the dominant market is not valid. Neither of the two markets may dominant the other.

4 DATA

This chapter describes the selection of the sample, collection of the data, and the filters used in data cleaning. Section 1 introduces the data of cross-listed sample. The method of how to establish a control sample will be introduced in Section 2. The control sample consists of industry and performance matched purely US securities.[2]

4.1 Cross-listed US and Canadian securities

4.1.1 Stocks

The initial sample consisted of 69 companies cross-listed on the TSX and either the NYSE or AMEX markets in 2007 (excluding IPOs). The final sample of 29 firms satisfied the following criteria:

a) Firms are listed on the TSX and either on the NYSE or AMEX.
b) Inter-listed firms have had at least a one-year history of trading in 2007.
c) They have daily bid and ask quotes, closing prices, and trading volume available from the Center for Research Security Prices (CRSP) and the TSX Common Equities database. Canadian stock data is from DataStream and Canadian Financial Markets Research Centre (CFMRC).
d) They have options trading on the Montreal Exchange (MX) and a US exchange.

4.1.2 Options

a) The Canadian trading quote records of the options derived from the underlying stocks were obtained from MX. In addition to option details, quotation records contain bid and ask prices while trade records contain transaction prices, and trading volume.
b) US options data was obtained through HistoricalOptionData.com.
c) The option quotes of the two markets have the same time stamps (4:00 P.M.), which makes it possible for the researcher to match option quotes or trades with the corresponding stock quotes. Violations of put-call parity using daily closing prices could stem from nonsynchronous prices.

[2] Due to data limitation, a well-matched pure domestically-listed Canadian sample cannot be constructed. It seems that Canadian firms with options trading on the MX are primarily those that are cross-listed on a US exchange.

d) The synthetic shares are constructed using near-the-money options with exercise prices close to the stock price. In particular, we use both the nearest in the money and the nearest out of the money strike prices.

e) The record dates of all observations within this sample are in 2007. The maturity days of this sample are 1-178 days. The options analyzed are short-term (i.e. 1~ 90 days) and intermediate-term options (i.e. 91~ 180 days), as longer term options often have zero trading volume.

f) For the analysis, US and Canadian options were matched to make them homogenous sets of option pairs. Therefore, only the options with the same record date and expiration date traded in the two countries were kept.

An analysis of the data set finds there are 57686 options or 28843 pairs for Canadian markets, and 38960 options or 19480 pairs for the US markets. Fewer options are traded in the US market than those in Canadian market, however, the total option trading volume (measured by the number of options traded during a trading day) in the US market is higher than that of Canadian market, which we discuss it in more detail in Chapter 6. The final sample of 29 firms and number of observations (firm-by-firm) are classified in Table 1:

Insert Table 1 about here

According to the regulations issued by NYSE, the cross-listed Canadian stocks must meet the minimum standards of earnings, market capitalizations and share distribution. No less than $500 million in market capitalization and minimum $25 million operating income per year are required. It suggests that only those well-operated large companies are qualified, which could introduce a bias.

4.1.3 Dividends

Among the 29 firms listed in Table 1, 8 do not pay dividends. The remaining 21 firms have complete dividend payment records in 2007. The Canadian dividend information including the dividend amount and ex-dividend date are accessible from CFMRC. Dividend information in US market is accessible in CRSP for all 29 firms. The value of dividend is set to be zero for non-dividend paying companies.

4.1.4 Interest rates

London Interbank Offered Rates (LIBOR) are used as the risk-free interest rate determinant in this paper. LIBOR in US dollars and LIBOR in Canadian dollars for 2007 are obtained from the British Banker's Association (BBA) website http://www.bba.org.uk.

4.1.5 Exchange rates

Daily exchange rates are used to translate shares in one country into their counterparts in the other country, when we examine cross-border violations of put-call parity. The daily exchange rates for the US and Canadian currencies are obtained from Bank of Canada http://www.bankofcanada.ca/en/rates/exchange.html

4.2 The US securities only listed and traded in domestic market (Purely US Sample)

Although the listing requirements for the US companies are not as strict as those for non-US firms, certain criteria must be satisfied. For example, aggregate cash flow for last 3 years should be no less than $25 million, and the fiscal amount for each individual year should be positive. Meanwhile, a minimum $500 million market capitalization requirement should be met or exceeded. In addition, firms selected to consist of the purely US listed sample must have associated options available. It seems that mostly larger enterprises have options available, so this sample may share the large firm bias of the cross-listed sample.

4.2.1 Stocks

In order to make a comparison of arbitrage opportunities between cross-listed stocks and domestically listed stocks, the research design requires a control sample of 29 companies that are subject to the following constraints:

a) All the 29 firms are listed only on the NYSE.[3]

b) These firms have at least a one-year trading record.

c) A purely US firm is matched to a corresponding inter-listed Canadian firm that is identified within the same industry. The industry is classified by NYSE.

d) All purely US domestic-listed firms identified in above 3 steps are matched to other dual-listed Canadian firms that have a similar Tobin's q. Tobin's q is a measure of firm performance and market power, and the theoretical value should be calculated by the

[3] The initial data of control sample is collected from CRSP, in which firms listed on either NYSE or AMEX are included. However, the firms qualified for our control sample, with the closest Tobin's q, are all listed on the NYSE.

formula $q^* = \frac{market\ value\ of\ assets}{replacement\ cost\ of\ assets}$ (see Tobin 1969).[4] Here, we adopt the value of $q = \frac{market\ capitalization + book\ value\ of\ liabilities}{book\ value\ of\ assets}$ as a proxy of Tobin's q (see for example Moeller et al., 2004). Firms in the same industry with the closest Tobin's q are included in our matching sample; in each case the value of Tobin's q of the control firm is within ±30% of the value of Tobin's q of its counterpart.[5] The mean and standard deviation of the variation are –1.1% and 18.6%, respectively. Theoretically, if Tobin's q is above 1, it shows that the firm operates well and earns a high return on capital investment. A high Tobin's q is usually considered as a signal that the firm's growth rate is high. If Tobin's q is below 1, it is usually a negative signal for investors that the firm suffers from poor investment, with a low growth rate.

e) The records of these firms such as closing prices and dividend payment information are retrieved from CRSP.

f) These firms have option trading records in 2007.

The details of the control sample matched by industry and Tobin's q are shown in Table 2.

Insert Table 2 about here.

4.2.2 Options

a) All the option records are provided by HistoricalOptionData.com.

b) To compare them with the cross-listed sample, options in the purely US sample satisfied the same criteria as their counterparts, that is, they are all nearest in- and out-of-the-money options, the record dates are within 2007, with their maturities no longer than 180 days.

Table 2: Panel B shows the 29 firms comprising the purely US sample. Descriptive statistics of maturities and trading volumes of call and put options are given in Table 3, sorted by subsamples.

Insert Table 3 about here.

[4] The values of market capitalization are obtained from CRSP, and data of Dec 31, 2007 is used. The book values of assets and liabilities are collected from the firms' annual report for 2007.

[5] Many existing studies use the same range of ±30% to match samples. Chen et al. (2006) and Summers and Sweeney (1998) employed a ±30% range to establish their control samples.

5 METHODOLOGIES

This chapter is designed to explain the methodology used in deriving the results. It discusses the upper and lower bounds for stock prices, derived from put-call parity. The two inequalities provide the rational range for stock prices (given option prices). If either of the two inequalities is not satisfied, arbitrage may exist. In addition, put-call parity is also examined in a cross-border situation.

Upper and lower bounds for stock prices are derived and shown in this chapter. If the actual share price violates upper or lower bounds, arbitrage may exist.

The following notation is used:

$C(bid)$: bid price of a call option

$P(bid)$: bid price of a put option

$C(ask)$: ask price of a call option

$P(ask)$: ask price of a put option

S_t: spot price of a stock

K: strike price of an option

$\boldsymbol{\sigma}$: implied volatility of an option

Margrabe (1978) derived the put-call parity theorem for American options, and a pricing model for European options. In this paper, we develop the put-call parity and test on cross-listed securities, based on Canadian and U.S. cases.

The put-call parity bounds for American options can be found in most standard derivatives securities texts (such as Hull, 2008). This relationship is described as follows

$$S - PV[div] - K \leq C - P \leq S - PV[K] \tag{5.1}$$

where S is the stock price, $PV\ [div]$ is the present value of all (assumed to be known with certainty) dividends payable prior to (or on) the common expiration time for the put and call, K is the common strike price, C is the call price and P is the put price of options with a common underlying asset, strike price, and expiration time. Rearranging this equation and inserting notation for ask or bid prices gives the following two candidate put-call parity bounds:

$$S(bid) - \mathrm{PV}[div] - K - C(ask) + P(bid) \leq 0, \tag{5.2}$$

$$C(bid) - P(ask) - S(ask) + \mathrm{PV}[K] \leq 0. \tag{5.3}$$

To prove inequality (5.2), consider the portfolio in which stocks are sold short, PV[*div*] + *K* is lent at the risk-free rate, the call is bought, and the put is written. Since buying is conducted at the ask and selling at the bid, this initial cash inflow (outflow if negative) from this portfolio is $S\,(bid) - \mathrm{PV}[div] - K - C\,(ask) + P\,(bid)$.

Suppose this portfolio is held until the put is exercised against it, at which time there will be an obligation to buy the stock for *K*, or otherwise hold until expiration. First, consider the case when the put is exercised at time τ, assuming this is after the (last) ex-dividend date, PV[div] grows to *div*, which is withdrawn to pay the dividend obligations of the short sell. Furthermore, *K* grows to $\mathrm{FV}[K] \geq K$, which is used to pay the strike price to buy the stock as required by the put contract. This closes out the short position in the stock. Finally, the call option is sold for $C_\tau(bid) \geq 0$, for a net inflow of $\mathrm{FV}[K] - K + C_\tau(bid) \geq 0$. If the put is exercised prior to the (last) ex-dividend date, then $\mathrm{FV}[\mathrm{PV}[div]] \geq 0$ is received; the obligation to pay the dividend does not exist anymore.

Consider the case when the put is never exercised, hence it expires out of the money. Again, use the investment of PV[*div*] to pay the dividend obligations of the short sell. Since the put is out of the money, the call will be in the money. Exercise it by withdrawing FV[*K*] and paying *K* to buy the stock. This closes out the short position in the stock, leaving a net inflow of $\mathrm{FV}[K] - K \geq 0$.

Since these two cases exhaust all possibilities, and since both have non-negative future value, to avoid arbitrage the initial value of the portfolio must be non-negative; thus, the initial cash inflow must have been non-positive.

To prove inequality (5.3), a portfolio is created by selling the call, buying the put, borrowing PV[*K*], and buying the stock. The initial cash inflow from this portfolio is $C(bid) - P(ask) - S(ask) + \mathrm{PV}[K]$. The portfolio is held until the call is exercised, at which time the stock should be sold for *K*, or until it expires.

Assume the call option is exercised at time τ, so the put must be out of the money. The payment is received by selling the stock at strike price *K*. In the mean time, principle and interest of PV[*K*] should be repaid, which is $\mathrm{FV}[\mathrm{PV}[K]] \leq K$ at time τ. To close out all our position, we sell the put for $P(bid) \geq 0$, then, including the possibility of receiving a dividend, the

net inflow of $K - \text{FV}[\text{PV}[K]] + P(bid) + \text{FV}[div] \geq 0$.

If the call expires out of the money, the put must be in the money. At the maturity, we exercise the put by selling the stock for K. Moreover, PV[K] grows to K, and we must repay the interest and principle, which offset the price in which the stock was sold. Accounting for any dividends paid, the final cash inflow should be FV[div] ≥ 0.

Both cases have non-negative future values. To avoid arbitrage, the initial value of the portfolio must be non-negative, which leads to a non-positive initial cash inflow. Thus, $C(bid) - P(ask) - S(ask) + \text{PV}[K] \leq 0$ holds.

If any quotes fall outside the bounds derived above, then arbitrage may exist. Arbi2 denotes that an arbitrage comes from Inequality (5.2); similarly, arbitrage opportunities derived from Inequality (5.3) are called Arbi3.

In this paper, cross-border violations of put-call parity are also examined. It is possible for investors to buy a stock in the US market and sell the equivalent synthetic share in the Canadian market, or hold an actual Canadian stock and synthetic short in US. The upper and lower bounds for stocks are modified to mimic a cross-border trading.

$$S^f(bid) - \text{PV}[div^f] - K - C(ask) + P(bid) \leq 0, \tag{5.4}$$

$$C(bid) - P(ask) - S^f(ask) + \text{PV}[K] \leq 0. \tag{5.5}$$

$S^f(bid)$ denotes for foreign bid price of the stock which is translated into local currency. For the cross-border Canadian sample, $S^f(bid)$ equals to $S(bid) \times$ CAD/USD, where $S(bid)$ represents bid price obtained from NYSE. Similarly, div^f is the translated dividend amount collected from foreign country. However, for dual-listed Canadian stocks, dividend could be paid either in Canadian or US dollars, equal in value after currency conversion, so div^f and div should be identical. $S^f(ask)$ stands for the converted ask price posted in foreign market. Concerning the cross-listed US sample, $S^f(bid)$ refers to $S(bid)$ / (CAD/USD), as $S(bid)$ is the US quote and should be translated into Canadian dollars. Arbitrage derived from Inequality (5.4) is labelled as Arbi4, while Arbi5 refers to arbitrage opportunities generated from Inequality (5.5). Results are presented in Chapter 6.

6 RESULTS & ANALYSES

This chapter presents the empirical results of the tests that were carried out on cross-listed samples and the purely U.S. sample. These arbitrage opportunities are derived from upper and lower bounds for stock prices. Section 6.1 discusses the arbitrage opportunities reported from the cross-listed Canadian sample. Section 6.2 presents the arbitrage existing in the dual-listed U.S. sample, and arbitrage in the control sample is discussed in Section 6.3.

6. 1 Arbitrage existing in the cross-listed Canadian sample

Insert Table 4 about here

Table 4 presents the arbitrages obtained from inequalities (5.2), (5.3), (5.4) and (5.5). Based on notations given in the methodology section, the variables arbi2(%), arbi3(%), arbi4(%), and arbi5(%) represent the arbitrage proportion of each stock, in percentage.

$$\text{arbi2}(\%) = \frac{\text{Arbi2}}{\text{obs}} \tag{6.1.1}$$

$$\text{arbi3}(\%) = \frac{\text{Arbi3}}{\text{obs}} \tag{6.1.2}$$

$$\text{arbi4}(\%) = \frac{\text{Arbi4}}{\text{obs}} \tag{6.1.3}$$

$$\text{arbi5}(\%) = \frac{\text{Arbi5}}{\text{obs}} \tag{6.1.4}$$

The arithmetic means of arbi2(%), arbi3(%), arbi4(%) and arbi5(%) reported in Table 4 are 0.13%, 0.55%, 0.13% and 0.19%, respectively. Results of statistic tests show that all arbitrage proportions are not significantly different from zero, at 5% significance level. After examining the results, we find that the observations of each stock are quite different, in other words each stock contributes different weights to the entire sample. To make results more robust to outliers, the observation-weighted average numbers of these arbitrage percentages are also considered. The weight on each stock equals the proportion of its observations to the total observations of the entire sample. Here, the weighted average numbers are given as 0.12%, 0.17%, 0.11%, and 0.07% for arbi2(%) to arbi5(%) respectively, and they are not significantly different from zero at 5% significance level. The numbers above and the results of Wilcoxon-Mann-Whitney U tests show that the number of violations due to short selling restrictions (Equation (2.3.2)) is not greater than the number of violations generated from the

opposite inequality. Thus, the argument that violations of put-call parity should be prevalent in only one direction does not hold.

The results shown in Panel A and Panel B of Tables 4 suggest that both the upper and lower bounds of stock prices hold well in cross-listed Canadian samples. Less than 1% of the 28843 observations provide arbitrage opportunities. In most circumstances, the Canadian quotes are priced fairly based on put-call parity.

6. 2 Arbitrage opportunities existing in the cross-listed US sample

Insert Table 5 about here

Table 5 Panel A shows that only a few arbitrage opportunities are reported in the cross-listed US sample. When transactions were made within one country, only 6 observations contain arbitrage opportunities out of 19480 records. The empirical results of Table 5 Panel B show that fewer than 1% of the cross-border put-call parity observations were found were found to provide arbitrage opportunities in cross-listed US sample. Generally, put-call parity holds very well in this sub-sample.

6. 3 Arbitrage opportunities existing in the purely US sample

Insert Table 6 about here.

The findings for the purely US sample are very similar to the cross-listed US sample. The weighted average of arbi2(%) and arbi3(%) are 0.01% and 0.03%, respectively. These arbitrage proportions are very slim and very close to the values of the cross-listed US sample, which indicates that both of the upper and lower bounds for all US quotes are not violated. However, we fail to conclude that there is significant difference in these arbitrage proportions at 5% significance level,[6] because the arbitrage proportions of all three samples are close to zero. Generally, the empirical results show that stocks are priced properly, regardless of their location. It seems that the US control sample does not contain fewer arbitrage opportunities, compared to the other two cross-border listed samples. Thus, we fail to reject Hypothesis 1 and draw a conclusion that cross-listing activities do not bring more arbitrage opportunities.

[6] As our data is not normally distributed, we employ a non-parametric Wilcoxon-Mann-Whitney U test. We fail to find a significant difference in the proportion of arbitrage opportunities between the cross-listed sample and the US control sample (the p-value of the two-sided test is 0.062). Based on the results of the two-sided tests, we fail to reject the hypothesis that the arbitrage proportion of the inter-listed Canadian sample is not significantly different from that of the inter-listed US sample (the p-value equals to 0.944).

Although the mean values of arbitrage percentage in the inter-listed Canadian sample contain are slightly less than those of the inter-listed US quotes, there is not sufficient evidence suggesting that the number of arbitrage opportunities in the inter-listed Canadian sample is statistically less than the number of arbitrage opportunities generated from the inter-listed U.S. sample, when we adopt Wilxocon-Mann-Whitney U tests. Hence, we fail to reject Hypothesis 2.

7 Robustness Check

In this chapter, we examine whether the results about the comparison of arbitrage percentages are robust. The potential reasons behind them are provided in the first section. Then, we relax the near-the-money restriction and allow all options to apply, so long as they have some trading volume in order to help rule out stale quotes. The arbitrage results of the full sample are presented in Section 2.

7.1 Robustness of arbitrage opportunities

7.1 .1 Arbitrage opportunities sorted by date

After examining the arbitrage opportunities that result from violating the upper and lower bounds for stock prices, we try to discover the reasons behind them, as part of a robustness check. We find that arbitrage opportunities in the cross-listed Canadian sample show a unique pattern when there are listed by date. Tables 4, 5 and 6 report these arbitrage proportions by firm, while Table 7 sorts them by date.

Insert Table 7 about here.

Table 7 Panel A shows that a number of arbitrage opportunities in cross-listed Canadian sample are concentrated on a single day, March 14, 2007, while arbitrage occurred sporadically on other trading days. However, Panels B and C show that the US market does not have this feature of a large number of arbitrage opportunities occurring on a particular day.

7.1.2 Market shocks in the first quarter of 2007

Why is the day March 14, 2007 so peculiar? Figure 1-1 presents the general trend of the S&P 500 in 2007, and the corresponding price movements are captured by Figure 2. As an indicator of the US stock market, the S&P 500 suffered two severe intraday price drops in the first quarter: one on February 27, 2007 (–3.47%), and the other on March 13, 2007 (–2.04%). The first sharp drop coincided with Black Tuesday of the Shanghai Stock Exchange. On February 27, 2007 the Shanghai Stock Exchange Composite Index declined around 9% in a single day, and the world market may have been affected by the dramatic turndown. Powell (2007) pointed out that this price crash was trigged by rumours that the Chinese government was going to increase the interest rate to control inflation. Many Wall Street analysts may have worried about the effects of the slowdown in the Chinese economy. Former Federal Re-

serve Chairman Alan Greenspan predicted a US recession in 2007. Consequently, orders of durable goods fell along with stock prices. Tokic (2007) examined the integration between Asia and the rest of the world, and the author pointed out the February Chinese stock market drop largely slowed down the rest of the world.

Based on the market report, on February 27, the Dow Jones industrial average fell 416.02 points, the biggest one day loss since 2001, while the S&P 500 dropped 3.5% that day. The crash was copied by other countries. For instance, the NIKKEI tumbled 2.9%, and Singapore Stock Index slipped 3.7%. The price drop lasted for about a week.

The second sharp worldwide decline started with the NYSE on March 13, 2007, after 5 days of climbing. The Dow Jones industrial average fell more than 57 points during the first trading hours, and then suffered a one day loss of 1.97%. The broader indicator, S&P 500 dropped more than 2% that day. Financial companies led the way down in index points. The first shock came from New Century Financial Corp, one of the largest subprime lenders in the US, as the company disclosed its severe financial distress along with the rising default rates. The steep fall was widespread in the financial sector. The weak open that day caused Wall Street investors to sell off the subprime mortgage market. The fear was fuelled by a report issued by the Mortgage Bankers Association on mortgage delinquencies and foreclosures for late 2006 (see Krinsman, 2007).

Subprime mortgages are mortgage loans granted to poor-credit borrowers. Because of the borrowers' poor credit records, these mortgages are treated as high risk loans. Reinhart et al. (2008) pointed out that the number of subprime mortgages increased sharply in the US starting in 2003. In 2006, around 20% of mortgage loans were subprime. However, according to a report by Inside Mortgage Finance, about 80% of those subprime loans were given as adjustable-rate mortgages. These adjustable rate mortgages usually require no down payment, and begin with an interest rate below the market rate. After the introductory period, the interest rate is adjusted up about 5% per year. Adjustable rate mortgages offer low credit borrowers a free call option on the real estate asset. If housing prices keep going up, the option is in the money. During the introductory period, the monthly payment is not sufficient to pay back ei-

ther principal or interest. Investors are willing to make monthly payments to keep this valuable call option, because they are speculating the property will appreciate.

By the latter half of 2006, the marginal unit of loan in the US facilitated the formation mentioned above, which is called the Ponzi phase in Minsky (2008). Minsky (2008) argued that a stable economy journeys from a hedging phase, a speculative phase, and then a Ponzi phase to instability. In early 2007, beyond most investors' expectations, the US housing market slowed down, and the prices declined. The subprime borrowers found that their properties depreciated, and the call option granted by the subprime mortgages was no longer valuable. Thus, they refused to make monthly payments, which resulted in an increase in the default rate. The sudden increase in defaults, delinquencies, and foreclosures made more than 24 financial companies face financial hurdles, and caused the US market to slip sharply on March 13, 2007, after five days of climbing.

Figure 3 illustrates the index price movements of the S&P/TSX composite index from the Canadian market and the Dow Jones industrial average from the US market. From the figure above, it is clear that the price movements in the two markets followed a similar pattern, which supports the argument that the integration level between Canadian and the US is high. With enhanced market globalization, the economic tie between countries becomes tighter. Extensive research supported this argument. After investigating real interest rates in several countries, Rodrik (2000) suggested that the world integration level has improved significantly. Perraton and Goldblatt (1997) analyzed multinational bank business and supported that the economic ties become tighter. Matsuyama (2004) examined the capital flows between rich countries and poor countries, and indicated that there is a rise in financial market globalisation. In this paper, the cointegration issue between the Canadian and US markets is also examined, because if the integration level is low, price discrepancies between the two countries may lead more arbitrage opportunities. Cointegration means that two price series are economically linked or follow the same trend in the long run, but we only deal with one-year data in this paper. The two price series the Dow Jones Industrial average and the S&P/TSX contain a unit root and they are $I(1)$: the original prices are both nonstationary, but their changes are stationary. The results of the augmented Dickey-Fuller (1981) tests and Philips

(1987) and Perron(1988) tests shows that the error term from regressing the Dow Jones Industrial average on S&P/TSX is covariance stationary, so generally speaking, the stock prices in the two countries are cointegrated. The US, Canada's biggest trading partner, absorbs 80% of Canada's exports. Most of the Canadian companies, especially metal and energy companies were directly affected by the US economy. That is why the two stock price crashes in the first quarter of 2007 not only happened in the US market but also in Canadian market. Due to the importance of the US to the Canadian economy, the sharp drop of the stock prices in the US market on March 13, 2007 sent the S&P/TSX composite index tumbling 255.55 points, or 2% in a single day. Among all Canadian firms, blue-chip companies, especially resource based companies reported a greater loss that day.

Table 8 presents the price drops of eight Canadian leading companies on March 13, 2007. Bloomberg summarised the market reactions of these blue-chip companies dual-listed in NYSE. Barrick Gold Corp., the nation's biggest precious metal producer, lost 3% in one day. Nortel Networks Corp. retreated more than 1.5 Canadian dollars (4.5%). Canadian oil and gas producers also posted a great loss that day: Suncor Energy, one of the largest oil sands producers, dropped 2.5%; while Talisman Energy Inc. slipped 1.8%. The banking system is also a victim of the worry of subprime mortgage lending in the US, the Royal Bank of Canada, as well as Toronto-Dominion Bank reported more than 1% losses.

Table 7 Panel A shows that on March 14, 2007, 64 arbitrage opportunities are found among the 88 arbitrage opportunities observed in all of 2007. Figure 1 and Figure 3 show that there was a difference in the price changes existing between the two countries. In general, the US market rebounded the day following the price crash, that is, March 14, 2007, while the Canadian market took another day to recover. It seems that an adjustment delay exists in Canada, and the price movement discrepancy may be responsible for the arbitrage opportunities in the Canadian sample. Quan (1999) supported our claim. The author investigated the stock returns in Canada and the US, and concluded that there is a positive relationship between the stock returns of the two countries. Moreover, they found the Canadian stock prices are positively related to the US prices, with a time lag.

Furthermore, we found that around three quarters of these arbitrage opportunities came from leading companies (see Figure 4). It seems that the arbitrage opportunities are more likely to be found among companies that were directly influenced by the sudden shock and who suffered more than their peers.

We also examine the price behaviour of the two markets in March 14, 2007. Table 9 presents the stock price movements in the two countries. If the prices move in the same direction in the two countries (price rebounded in both markets or dropped together), we record the price changes as having positive co-movement (+); if not, then we consider the prices changes to have negative (or no) co-movement (–). We find that almost all violations of put-call parity are reported in those firms with negative co-movement. The stock price disparities of the two countries may help us to explain the violations of cross-border put-call parity.

7.1.3 Cause of arbitrage formation on March 13, 2007

As shown in Table 7, we fail to find the arbitrage concentration phenomenon in the US market from Panels B and C. Why did put call parity survive in the US, but fail in Canada?

On March 13, 2007, prices in the US stock market and Canadian markets fell sharply after New Century's announcement. In an efficient market, stock and option prices should quickly react to the new shock. Sabherwal (2007) indicated that there is a positive relationship between the speed at which market quotes absorb fresh information and the number of analysts and active traders in the market, while the numbers of analysts and investors in the United States and Canada are related to the trading volume of dual-listed Canadian firms in the two markets. Comparing the trading volume in the two markets, the author draws a conclusion that the majority of analysts and investors rely on US markets and the US market reacts to new information more quickly than Canada.

According to Holden and Subrahmanyam (1992), arbitrage transactions could be impeded by low trading volume. Figure 5 shows that for most of the 29 firms, the trading volume of options in the US markets is greater than that in Canadian markets, which has been supported by empirical evidence of one-sided tests (Table 10). When new information comes, both stock prices and option prices adjust. The different market structure of stock markets and

option markets may lead to a temporary price violation of put-call parity. The US markets, with sufficient liquidity, allow traders and investors to make arbitrage transactions when arbitrage opportunities appear. Active investors and traders drive the prices back to their rational range by taking arbitrage transactions, and then arbitrage disappears. However, the Canadian market, is not as liquid as the US market, it may not be possible to take advantage of all arbitrage transactions in the Canadian market, especially in the option markets. In this paper, daily closing prices are used rather than intraday data. It is possible that arbitrage opportunities exist in the intraday observations in both markets. In the US markets, any mispricing is fixed by arbitrage transactions during trading hours, so put-call parity holds well at the end of the day. On the other hand, there may not be enough arbitrage transactions taking place in the Canadian market, so several arbitrage opportunities last until close. Unfortunately, without intraday data, the argument above is speculation.

Why did the arbitrage concentration phenomenon only occur on March 14, 2007? Figure 6 presents the 10 biggest stock price drops in the Canadian market in 2007. The stock prices on March 14, 2007, one day after the second stock crash, still followed a downward trend. A steady climbing started from March 15. This stock slump was right after another stock price decline two weeks earlier. A large number of analysts and active investors in Canada were still dealing with the disorder that is caused by the previous shock. When market shocks came in rapid succession, the number of analysts and the liquidity of the Canadian market may curb its capacity of arbitrage transactions. The time line of the 10 biggest drops in the Canadian market in 2007 sounds in consistent with our explanation, as the time interval between the first two prices drops is the shortest one (Figure 7). The longer time interval may provide analysts and investors enough time to exploit all mispricing and then make appropriate arbitrage transactions. This claim has been supported by some behavioural finance experts. As the former vice-chairman of Fidelity's Investment, Peter Lynch said, “The key to making money in stocks is not to get scared out of them.” The high market volatility within a short time period will lead to media speculation. In a special market climate, both investors and market makers become more risk averse. Some investors could over-react to the market shocks and withdraw their savings from security markets and make more conservative in-

vestments. Market makers could also cut their inventories to avoid inventory risk when market volatility is high. Thus, if the time interval between market shocks is short, both investors and market makers avoid taking transactions. Without enough arbitrage transactions, mispricing could not be fixed completely during trading hours, so arbitrage opportunities could be detected in closing prices.

Chordia et al. (2005) found that market liquidity shrinks during crisis periods. Thus, there may not be enough arbitrage transactions taking place to drive prices back to their no-arbitrage level. Figure 8 supports this claim. We examine the option trading volume during market crash, and find that fewer option transactions took place during the 10 biggest price declines, compared to their corresponding monthly average trading volume. Statistical support is shown in Table 11. It shows that trading volume is inversely related to market volatility. It takes time for investors and market makers to recover confidence and increase trading volume. If another shock occurs during the recovery period, there may not be enough transactions in the market to eliminate arbitrage opportunities. A longer time interval between market shocks could provide enough room for confidence to recover, which may help put-call parity hold well and fewer arbitrage opportunities to be observed in closing prices.

7.2 Robustness check by adopting full sample

As we mentioned in Chapter 4, the options employed to establish put-call parity are all near-the-money options. After examining the trading volume of raw data, we found that those near-the-money options are more actively traded than other options left in the data set. According to Sadka (2003), low trading volume may impede arbitrage transactions. It is possible that those less-liquid options would retain some arbitrage opportunities. To address this issue, we perform a robustness check by relaxing the near-the-money restrictions and including non-near-the-money options with positive trading volume in all three samples. The sample size of cross-listed Canadian sample expands from 28842 to 30625. The full sample of cross-listed US sample contains 35854 records, and there are 37838 observations in the purely US sample. The descriptive statistics of the three full samples are given in Table 12. The average trading volumes, for both call and put options, decline in the full samples. First, we check whether these outlier options drive our main results. Overall, there is no qualitative

change in arbitrage opportunities reported in the three samples. There are very few violations of the upper and lower bounds of stock prices reporting in either cross-listed US sample or purely US sample. It seems that put-call parity holds very well in the US market. Furthermore, Table 13 shows that less than 1% of the observations allow arbitrage in the cross-listed Canadian sample. Generally speaking, put-call parity works well in all three full samples.

We also examine the robustness of the arbitrage concentration phenomenon. The empirical results are given in Table 16. About 70% of the observations on March 14, 2007 contain arbitrage, while arbitrage opportunities occur only occasionally on other days. The numbers in Panel B and Panel C in Table 16 show similar results to Table 7. Thus, the arbitrage concentration is robust when the near-the-money restriction is relaxed.

8 CONCLUSIONS & LIMITATIONS

We examine arbitrage opportunities in the Canadian and US markets for Canadian cross-listed stocks arising from violations of upper and lower bounds for American-style option put-call parity. To investigate the cross-listing effect on arbitrage opportunities, we also consider an industry-matched comparison sample composed of purely US stocks. Moreover, inter-listed Canadian quotes are distinguished from their US counterparts to analyze the relationship between dominant and satellite countries.

According to the results from both upper and lower bounds, arbitrage opportunities in the inter-listed Canadian sample are very rare, and those arising in the cross-border listed US samples are even more, while the control samples reports rare arbitrage opportunities. Moreover, the difference in arbitrage proportions between cross-listed samples and the control sample is not significant. Accordingly, our first hypothesis that cross-listings allow more arbitrage than domestically listed stocks should be rejected. Likewise, the comparison between cross-listed US quotes and Canadian quotes suggests that put-call parity holds well in both countries.

However, we do find an outlier with several arbitrage opportunities available on March 14, 2007. The integration relationship between Canada and the US has been supported in this study. The market of one country could be affected by material information from other countries. Conversely, the movements in one country could influence the price behaviour of other countries. When a particular event happens, price adjustments take place in all related markets, and the reaction speed is related to the market efficiency and liquidity. The Canadian market reaction to the stock price slump in March was slightly different from the US It sounds reasonable that segmentation still exists between Canada and the US, which is consistent with the semi-integration relationship between Canada and the US advocated in previous studies. Due to the segmentation, the price disparities after a crash may result in arbitrage in Canada. Based on our methodology, arbitrage opportunities exist if either the upper or the lower bounds for stock prices (as determined by put-call parity) are violated. If the stock price lies above the upper bound, that is, the stock is overpriced relative to options, investors may benefit from buying a call, writing a put, lending the present value of the divi-

dend, and selling the stock. Likewise, it is possible to earn profit by taking an advantage of a relatively underpriced stock. To construct a profitable transaction, investors write a call, long a corresponding put and borrow the cash amount equals to the present value of the option's exercise price. In that case, a net cash inflow is guaranteed. After taking these transactions, arbitrage opportunities disappear and the stock prices are driven back to their normal level. After investigation of option trading volumes, we find that there were fewer transactions made in Canada than in the US, and during stock market crashes, the option trading volume dropped below average in 2007. With insufficient trading, mispricing could be captured in the closing quotes.

Clearly, our study has a number of limitations. Based on our methodology, arbitrage came from the disparity of stock and option prices. According to the empirical evidence, on March 14, 2007 most arbitrage is reported in the Canadian companies whose stock prices moved in opposite directions in the two countries. However, if both Canadian stock and option market movements differed equally from the US quotes, there would be no violations of put call parity. Without intraday data, the analysis of this observation is limited, and the impact of some factors may remain undetected. Another drawback is that our study does not include a pure Canadian control sample. A well-matched pure domestically-listed Canadian sample would help us to investigate the relationship between cross-border listings and violations of put-call parity. Unfortunately for this analysis, primarily the same firms that have liquid option trading are also cross-listed, so a relevant purely Canadian sample cannot be constructed.

In addition, the exchange rates we adopt for examining cross-border put-call parity are mid-market rates, rather than the bid and ask quotes. It is possible that the arbitrage proportions of the two cross-listed samples change if the bid and ask quotes of exchange rates are used. However, Bali and Yilmaz (2008) found that the bid-ask spreads in the CAD/USD foreign exchange markets, with an average value of 0.004 US dollars, is quite small in recent years. According to Ellul et. al (2007), the average bid-ask spread on US stock market from 2002 to 2007 is reported to be 0.0523 US dollars. Mayhew (2002) found that the bid-ask spreads in option markets are slightly smaller than that of stock markets, and the value given

in his paper is around 0.045 US dollars. Thus, the bid-ask spreads in the CAD/USD foreign exchange market is relatively smaller, compared to the bid-ask spreads in stock and option markets, so the results of our cross-border put-call parity examination are likely still quite reliable.

REFERENCES

Bali, G. and K. Yilmaz, 2009, The Intertemporal Relation between Expected Return and Risk on Currency, Working paper.

Baker, M. and S. Savasoglu, 2002, Limited arbitrage in mergers and acquisitions, *Journal of Financial Economics,* vol. 64, no. 1, p. 91-115.

Baruch, S., A. Karolyi, and M. Lemmon, 2007, Multimarket Trading and Liquidity: Theory and Evidence, *The Journal of finance*, vol. 62, no. 5, p. 2169.

Battalio, R. and P. Schultz, 2006, Options and the Bubble, *The Journal of finance*, vol. 61, no. 5, p. 2071.

Ben-Zion, U. and O. Lieberman, 1996, A Characterization of the Price Behaviour of International Dual Stocks: An Error Correction Approach. Center for Economic Studies Working Paper at University of Munich, Number 104.

Biddle, C. and S. Saudagran, 1989, The Effects of Financial Disclosure Levels on Firms' Choices among Alternative Foreign Stock Exchange Listings*, *Journal of international financial management accounting,* vol. 1, no. 1, p. 55.

Black, F. 1974, International capital market equilibrium with investment barriers, *Journal of financial economics,* vol. 1, no. 4, p. 337.

Chakravarty, S., H. Gulen, and S. Mayhew, 2004, Informed Trading in Stock and Option Markets, *The Journal of finance*, vol. 59, no. 3, p. 1235.

Chen, S. and L. Chou, and C. Yang, 2002, Price Transmission Effect between GDRs and Their Underlying Stocks—Evidence from Taiwan, *Review of Quantitative Finance and Accounting,* vol. 19, no. 2, p. 181.

Chordia,T. and A. Sarkar, and A. Subrahmanyam, 2005, An empirical analysis of stock and bond market liquidity, *The Review of Financial Studies,* vol. 18, no. 1, p. 85.

Chowdhry, B. and V. Nanda, 1991, Multimarket trading and market liquidity, *The review of financial studies,* vol. 4, no. 3, p. 483.

Danielsen, B. and S. Sorescu, 2001, Why do option introductions depress stock prices? A study of diminishing short sale constraints, *Journal of Financial and Quantitative Analysis*, p. 451.

Detemple, J. and L. Selden, 1991, A general equilibrium analysis of option and stock market interactions, *International economic review*, p. 279.

Dickey, D. and W. Fuller, 1981, Likelihood ratio statistics for autoregressive time series with a unit root, *Econometrica* 49, p.1057-1072.

Ellul, A. C. Holden, P. Jain, and R. Jennings , 2007, Order dynamics: Recent evidence from the NYSE, *Journal of empirical finance*, vol. 14, no. 5, p. 636.

Erickson, M. and A. Goolsbee, and E. Maydew, 2003, How Prevalent is Tax Arbitrage? Evi dence from the Market for Municipal Bonds, *National Tax Journal (pre-1986),* vol. 56, no. 1 Part 2, p. 259.

Errunza, V. and E. Losq, 1985, International asset pricing under mild segmentation: Theory and test, *The Journal of finance*, vol. 40, no. 1, p. 105.

Eun, C. and S. Sabherwal, 2003, Cross-Border Listings and Price Discovery: Evidence from US-Listed Canadian Stocks, *The Journal of finance*, vol. 58, no. 2, p. 549.

Foerster, S. and G. Karolyi, 1993, International Listings of Stocks: The Case of Canada and the US, *Contact*, vol. 24, no. 4, p. 763.

Froot, K., and E. Dabora, 1999, How are Stock Prices Affected by the Location of Trade? *Journal of Financial Economics*, vol.53, p.189–216.

Jarrow, R. 1992, Market Manipulation, Bubbles, Corners, and Short Squeezes, *Journal of Financial and Quantitative Analysis*, vol. 27, no. 9, p. 311

Gagnon, L. and A. Karolyi, 2004, Multi-Market Trading and Arbitrage. *Dice Center* No. 2004-9

Garbade, K and W. Silber, 1979, Dominant and satellite markets: a study of dually-traded securities, *The review of economics and statistics*, p. 455.

Grammig, J. and W. Silber, 2001, Knowing me, knowing you: Trader anonymity and informed trading in parallel markets, *Journal of financial markets*, vol. 4, no. 4, p. 385.

Harvey, C. and R. Campbell, 1990, The World Price of Covariance Risk. *Journal of Finance*, 4 6, 111-157.

Hasbrouck, J. 1995, One Security, Many Markets: Determining the Contributions to Price Discovery, *The Journal of finance*, vol. 50, p. 1175.

Hauser, S. and Y. Tanchuma, and U.Yaari, 1998, International transfer of pricing information between dually listed stocks, *The Journal of financial research*, vol. 21, p. 139.

Holden, C. and A. Subrahmanyam, 1992, Long-lived private information and imperfect competition, *The Journal of finance*, p. 247.

Howe, J. and J. Madura, 1990, The impact of international listings on risk: Implications for capital market integration, *Journal of banking finance*, vol. 14, no. 6, p. 1133.

Hull, J. 2008, Options, futures, and other derivatives. Prentice-Hall, Englewood Cliffs, NJ.

Jorion, P., E. Schwartz, and J. Bodurtha Jr., 1986, Integration Vs. Segmentation in the Cana dian Stock Market/Comment, *The Journal of Finance*, vol. 41, no. 3, p. 603.

Knez, Z. and Z. Chen, 1995, Measurement of Market Integration and Arbitrage, *The Review of Financial Studies (1986-1998)*, vol. 8, no. 2, p. 287.

Krinsman, A., 2007, Subprime Mortgage Meltdown: How Did It Happen and How Will It End? *Journal of Structured Finance*, no. Summer 2007.

Liberman, P. 1996, Does conquest pay?: the exploitation of occupied industrial societies. Princeton, NJ: Princeton University Press.

Licht, P., 2006, Bifurcation Accounting Proposed For Insurance, Re: Should You Be Worried? *National Underwriter*. P & C, vol. 110, no. 33, p. 16.

Margrabe, W., 1978, The Value of an Option to Exchange One Asset for Another, *The Journal of Finance*, vol. 33, no. 1, p. 177-186.

Matsuyama, K. 2004, Financial market globalization, symmetry-breaking and endogenous inequality of nations, *Econometrics* (pre-1986), p. 853.

Mayhew, S. 2002, Competition, market structure, and bid-ask spreads in stock option markets, *The Journal of finance*, p. 931.

Mayhew,S. and V. Mihov, 2004, How Do Exchanges Select Stocks for Option Listing? *The Journal of finance,* vol. 59, no. 1, p. 447.

Minsky, H. 2008, Stablizing an unstable economy. The Jerome Levy Economics Institute Working Paper No. 74.

Mittoo, U, 1992, Managerial Perceptions of the Net Benefits of Foreign Listing: Canadian Evidence, *Journal of international financial management accounting*, vol. 4, no. 1, p. 40.

Moeller, S., F. Schlingemann and R. Stulz, 2004, Firm size and the gains from acquisitions. *Journal of Financial Economics* vol. 73, no. 8, p. 201-228.

Neumark, P, P. Tinsley and T. Suzanne, 1991. After-Hours Stock Prices and Post-Crash

Hangovers, *Journal of Finance, American Finance Association*, vol. 46, no.1, p. 159-78, March.

Ofek, E. and M. Richardson, 2004, Limited arbitrage and short sales restrictions: evidence from the options markets, *Journal of financial economics*, vol. 74, no. 2, p. 305.

Pascual, R and B. Pascual-Fuster, and F. Climent, 2006, Cross-listing, price discovery and the informativeness of the trading process, *Journal of financial markets*, vol. 9, no. 2, p. 144.

Perraton, J. and D. Goldblatt, 1997, The globalization of economic activity, *New Political Economy*, vol. 2, no. 2, p. 257.

Perron, P, 1988, Trends and random walks in macroeconomic time series: Further evidence from a new approach. *Journal of Economic Dynamics and Control*, 12, 297– 332.

Phillips, P, 1987, Time series regression with a unit root. *Econometrica*, 55, 277–301.

Powell, W, 2007, Behind China's Stock Meltdown. *Time,* Feb 28.

Pulatkonak, M, 1999, The Distribution of Global Trading in NYSE-listed Non-US Stocks. NYSE Working Paper 99-03.

Reinhart, C. and K. Rogoff, 2008, Is the 2007 US sub-prime financial crisis so different? An international historical comparison, *The American Economic Review*, vol. 98, no. 2, p. 339.

Rodrik, D.,2000, How far will international economic integration go? *The Journal of Economic Perspectives*, p. 177.

Quan, D., 1999, Do Real Estate Prices and Stock Prices Move Together? an International Analysis. *Real Estate Economics*, vol. 27, no. 2, p. 183.

Sabherwal, S., 2007, The US Share of Trading Volume in Cross-Listings: Evidence from Canadian Stocks, *The Financial Review The Official Publication of the Eastern Finance Association*, vol. 42, no. 1, p. 23.

Sadka, R., 2003. Momentum, liquidity risk, and limits to arbitrage. Unpublished working paper, North-western University.

Spais, G, 2002, Stock options as a means of adding value in business markets: A powerful potential communication vehicle for business marketing managers, *Journal of financial services marketing*, vol. 6, no. 3, p. 290.

The Informer, 2008, Canadian Capital Markets - The S&P/TSX Year in Review, vol. 2, http://www.corpben.com/pdfs/February-08_Informer.pdf

Tobin, J. 1969, A general equilibrium approach to monetary theory, *Journal of money, credit, and banking*, p. 15.

Tokic, D, 2007, Would a rising yen mean global turmoil? *The Journal of Corporate Accounting Finance*, vol. 18, no. 6.

Xu, X. and H. Fung, 2005, Cross-market linkages between U.S. and Japanese precious metals futures trading, *Journal of International Financial Markets, Institutions and Money,* vol.15, no. 2, p. 107-124.

APPENDIX

Table 1: 29 firms composed of cross-border samples

This table displays the company information of 29 cross-listed firms that were dual-listed in both the U.S. and Canadian markets in 2007. The numbers of observations obtained from both markets are also shown in this table.

Symbol	Company name	Industry	Exchange	CA (obs.)	U.S.(obs.)
ABX	Barrick Gold Corporation	Gold Mining	NYSE/TSX	3085	1731
AEM	Agnico-Eagle Mines Limited	Gold Mining	NYSE/TSX	1977	1198
AGU	Agrium Inc.	Specialty Chemicals	NYSE/TSX	1053	775
BCE	BCE Inc.	Fixed Line Telecommunications	NYSE/TSX	104	112
BVF	Biovail Corporation	Pharmaceuticals	NYSE/TSX	538	431
CLS	Celestica Inc.	Electrical Components and Equipment	NYSE/TSX	26	25
CNQ	Canadian Natural Resources Limited	Exploration and Production	NYSE/TSX	1897	1538
CP	Canadian Pacific Railway Limited	Railroads	NYSE/TSX	268	230
ECA	EnCana Corporation	Exploration and Production	NYSE/TSX	1997	1985
ENB	Enbridge Inc.	Gas Distribution	NYSE/TSX	15	15
ERF	Enerplus Resources Fund	Exploration and Production	NYSE/TSX	149	117
FDG	Fording Canadian Coal Trust	Coal	NYSE/TSX	530	374
FFH	Fairfax Financial Holdings Limited	Property and Casualty Insurance	NYSE/TSX	7	7
IMO	Imperial Oil Limited	Oil and Gas Extraction	AMEX/TSX	126	134
IVN	Ivanhoe Mines Limited	Nonferrous Metals	NYSE/TSX	143	129
NCX	Nova Chemicals Corporation	Commodity Chemicals	NYSE/TSX	207	204
NG	NovaGold Resources, Inc.,	Metals Mining	AMEX/TSX	85	51
NT	Nortel Networks Corporation	Telecommunications Equipment	NYSE/TSX	1245	1245
NXY	Nexen Inc.	Exploration and Production	NYSE/TSX	714	682
POT	Potash Corporation of Saskatchewan Inc.	Specialty Chemicals	NYSE/TSX	6627	1582
RY	Royal Bank of Canada	Banks	NYSE/TSX	537	735
SLF	Sun Life Financial Inc.	Life Insurance	NYSE/TSX	31	36
SLW	Silver Wheaton Corp.	Platinum and Precious Metals	NYSE/TSX	830	657
SU	Suncor Energy Inc.	Integrated Oil and Gas	NYSE/TSX	3971	1872
TCK	Teck Cominco Limited	Nonferrous Metals	NYSE/TSX	1131	1782
TD	The Toronto-Dominion Bank	Banks	NYSE/TSX	440	630
THI	Tim Hortons Inc.	Restaurants and Bars	NYSE/TSX	56	57
TLM	Talisman Energy Inc.	Exploration and Production	NYSE/TSX	1033	1125
TOC	Thomson Corp	Information company	AMEX/TSX	21	21
Total				28843	19480

Table 2: The control purely US sample matched by industry and Tobin's q

This table shows the information of control purely U.S. sample matched by industry and Tobin's q. The values of Tobin's q are presented in this table, and differences in q between the two matched firms are displayed as percentage in the last column.

Cross-border listed Sample			Control Sample		
Symbol	Tobin's q	Industry	Symbol	Tobin's q	Δ
ABX	1.09	Gold Mining	GG	1.16	0.07
AEM	2.47	Gold Mining	KGC	2.01	-0.18
AGU	0.80	Specialty Chemicals	ASH	0.79	-0.01
BCE	0.40	Fixed Line Telecommunications	CTL	0.30	-0.25
BVF	0.97	Pharmaceuticals	LLY	1.20	0.23
CLS	0.14	Electrical Components and Equipment	BEZ	0.17	0.22
CNQ	0.41	Exploration and Production	CHK	0.31	-0.24
CP	0.35	Railroads	CSX	0.34	-0.03
ECA	0.60	Exploration and Production	BTE	0.68	0.13
ENB	0.40	Gas Distribution	NWN	0.44	0.12
ERF	0.64	Exploration and Production	EGN	0.60	-0.06
FDG	0.47	Coal	ACI	0.50	0.06
FFH	0.15	Property and Casualty Insurance	EIG	0.13	-0.08
IMO	2.08	Oil and Gas Extraction	ARD	2.47	0.19
IVN	2.26	Nonferrous Metals	PCU	1.90	-0.16
NCX	0.10	Commodity Chemicals	HUN	0.08	-0.15
NG	0.74	Metals Mining	CLF	0.52	-0.29
NT	0.57	Telecommunications Equipment	TNS	0.57	-0.01
NXY	0.35	Exploration and Production	ALJ	0.33	-0.05
POT	2.32	Specialty Chemicals	CCC	2.32	0.00
RY	0.05	Banks	KEY	0.04	-0.20
SLF	0.04	Life Insurance	SFG	0.05	0.30
SLW	1.44	Platinum and Precious Metals	SWC	0.79	-0.45
SU	0.70	Integrated Oil and Gas	CVX	0.83	0.19
TCK	0.11	Nonferrous Metals	USU	0.12	0.11
TD	0.05	Banks	BBT	0.06	0.20
THI	2.31	Restaurants and Bars	MCD	1.99	-0.14
TLM	0.50	Exploration and Production	BBG	0.64	0.28
TOC	0.95	Information company	ASF	0.84	-0.11

The mean and standard deviation of the variation (Δ) are -1.1% and 18.6%, respectively.

Table 2 Panel B: Summary of 29 firms in the purely U.S. sample

This table displays the company information for the control sample consists of 29 domestic listed US firms. The numbers of observations obtained from the U.S. market are also shown in this table.

Symbol	Company name	Industry	Exchange	U.S.(obs.)
ACI	Arch Coal Inc.	Coal	NYSE	1387
ALJ	Alon USA Energy Inc.	Exploration and Production	NYSE	472
ARD	Arena Resources Inc.	Oil and Gas Extraction	NYSE	524
ASF	Administaff Inc.	Information company	NYSE	500
ASH	Ashland Inc.	Specialty Chemicals	NYSE	484
BBG	Bill Barrett Corp.	Exploration and Production	NYSE	163
BBT	BB&T Inc.	Banks	NYSE	836
BEZ	Baldor Electric Co.	Electrical Components and Equipment	NYSE	40
BTE	Baytex Energy Trust	Exploration and Production	NYSE	80
CCC	Calgon Carbon Corporation	Specialty Chemicals	NYSE	90
CHK	Chesapeake Energy Corporation	Exploration and Production	NYSE	1561
CLF	Cliffs Natural Resources Inc.	Metals Mining	NYSE	1353
CSX	CSX Corp.	Railroads	NYSE	1385
CTL	CenturyTel, Inc.	Fixed Line Telecommunications	NYSE	151
CVX	Chevron Corp.	Integrated Oil and Gas	NYSE	1723
EGN	Energen Corp.	Exploration and Production	NYSE	60
EIG	Employers Holdings, Inc.	Property and Casualty Insurance	NYSE	5
GG	Goldcorp Inc.	Gold Mining	NYSE	1600
HUN	Huntsman Corp.	Commodity Chemicals	NYSE	311
KEY	KeyCorp	Banks	NYSE	630
KGC	Kinross Gold Corporation	Gold Mining	NYSE	1185
LLY	Eli Lilly & Co.	Pharmaceuticals	NYSE	1259
MCD	McDonald's Corp.	Restaurants and Bars	NYSE	1673
NWN	Northwest Natural Gas Co.	Gas Distribution	NYSE	10
PCU	Southern Copper Corp.	Nonferrous Metals	NYSE	1732
SFG	StanCorp Financial Group Inc.	Life Insurance	NYSE	31
SWC	Stillwater Mining Company	Platinum and Precious Metals	NYSE	641
TNS	TNS Inc.	Telecommunications Equipment	NYSE	5
USU	USEC Inc.	Nonferrous Metals	NYSE	1235
Total				21126

Table 3: Summary statistics for option pairs in three samples

This table displays the summary statistics of maturity and option trading volume, for the two cross-border listed samples and one control sample.

	Cross-listed Canadian			Cross-listed US			Pure US		
	Maturity	Volume_C	Volume_P	Maturity	Volume_C	Volume_P	Maturity	Volume_C	Volume_P
Mean	73.3354	51.4656	34.7291	75.093	290.041	178.943	64.4626	482.169	283.87
Maximum	178	6194	4507	178	30361	30154	178	234940	27981
Minimum	1	1	1	1	1	1	1	1	1
Median	59	20	15	59	70	39	49	121	60
S.D.	51.5362	139.363	93.4161	52.3949	854.853	625.492	50.0313	2178.34	834.431
Skewness	0.4256	14.5793	19.2524	0.376	12.9059	15.6802	0.7263	69.4011	10.2019
Kurtosis	-1.1142	350.21	584.291	-1.1876	291.384	453.552	-0.6835	6847.73	180.249
N	28843	28843	28843	19480	19480	19480	21126	21126	21126

Notes to Table A3: Cross-listed Canadian is the sample which consists of Canadian market quotes of the 29 cross-listed firms. Cross-listed US sample is composed of stock and option prices of the 29 cross-listed firms, and all prices are obtained from the U.S. markets. Purely US is the sample made up of stocks and options issued by the 29 matched firms.
Volume_C denotes the trading volume of call options.
Volume_P denotes the trading volume of put options.

Table 4: Arbitrage existing in cross-listed Canadian sample generated from violations of put-call parity

Panel A: Arbitrage existing in cross-listed Canadian sample generated from violations of domestic put-call parity

This table displays the arbitrage existing in cross-listed Canadian sample obtained from Inequality (5.2) and (5.3). Arithmetic average and observation weighted average of arbitrage percentage values generated from domestic put-call parity are given in this table. All information is listed by firm.

Symbol	obs	arbi2	arbi2(%)	arbi3	arbi3(%)
ABX	3085	2	0.06%	1	0.03%
AEM	1977	0	0	0	0
AGU	1053	0	0	0	0
BCE	104	0	0	4	3.85%
BVF	538	0	0	6	1.12%
CLS	26	0	0	1	3.85%
CNQ	1897	5	0.26%	0	0
CP	268	0	0	0	0
ECA	1997	4	0.20%	1	0.05%
ENB	15	0	0	0	0
ERF	149	0	0	5	3.36%
FDG	530	0	0	0	0
FFH	7	0	0	0	0
IMO	126	0	0	0	0
IVN	143	0	0	0	0
NCX	207	0	0	1	0.48%
NG	85	0	0	0	0
NT	1245	3	0.24%	1	0.08%
NXY	714	3	0.42%	5	0.70%
POT	6627	1	0.02%	1	0.02%
RY	537	7	1.30%	5	0.93%
SLF	31	0	0	0	0
SLW	830	5	0.60%	0	0
SU	3971	1	0.03%	1	0.03%
TCK	1131	3	0.27%	13	1.15%
TD	440	1	0.23%	0	0
THI	56	0	0	0	0
TLM	1033	0	0	4	0.39%
TOC	21	0	0	0	0
Arithmetic average			0.13%		0.55%
Total	28843	35		49	
Weighted average		0.12%			0.17%

Table 4 Panel B: Arbitrage existing in cross-listed Canadian sample generated from violations of cross-border put-call parity

This table displays the arbitrage existing in cross-listed Canadian sample obtained from Inequality (5.4) and (5.5). Arithmetic average and observation weighted average of arbitrage percentage values generated from cross-border put-call parity are given in this table. All information is listed by firm.

Symbol	obs	arbi4	arbi4(%)	arbi5	arbi5(%)
ABX	3085	0	0	0	0
AEM	1977	0	0	0	0
AGU	1053	0	0	0	0
BCE	104	0	0	0	0
BVF	538	0	0	6	1.12%
CLS	26	0	0	0	0
CNQ	1897	0	0	0	0
CP	268	0	0	0	0
ECA	1997	4	0.20%	1	0.05%
ENB	15	0	0	0	0
ERF	149	0	0	5	3.36%
FDG	530	0	0	0	0
FFH	7	0	0	0	0
IMO	126	0	0	0	0
IVN	143	0	0	0	0
NCX	207	0	0	0	0
NG	85	0	0	0	0
NT	1245	3	0.24%	0	0
NXY	714	15	2.10%	0	0
POT	6627	0	0	0	0
RY	537	1	0.19%	2	0.37%
SLF	31	0	0	0	0
SLW	830	5	0.60%	0	0
SU	3971	0	0	1	0.03%
TCK	1131	4	0.35%	4	0.35%
TD	440	0	0	0	0
THI	56	0	0	0	0
TLM	1033	0	0	1	0.10%
TOC	21	0	0	0	0
Arithmetic average			0.13%		0.19%
Total	28843	32		20	
Weighted average		0.11%			0.07%

Table 5: Arbitrage existing in cross-listed US sample generated from violations of put-call parity

Panel A: Arbitrage existing in cross-listed US sample generated from violations of domestic put-call parity

This table displays the arbitrage existing in cross-listed US sample obtained from Inequality (5.2) and (5.3). Arithmetic average and observation weighted average of arbitrage percentage values generated from domestic put-call parity are given in this table. All information is listed by firm.

Symbol	obs	arbi2	arbi2(%)	arbi3	arbi3(%)
ABX	1731	0	0	0	0
AEM	1198	0	0	0	0
AGU	775	0	0	0	0
BCE	112	0	0	0	0
BVF	431	0	0	0	0
CLS	25	0	0	0	0
CNQ	1538	0	0	0	0
CP	230	0	0	0	0
ECA	1985	0	0	0	0
ENB	15	0	0	0	0
ERF	117	0	0	0	0
FDG	374	0	0	0	0
FFH	7	0	0	0	0
IMO	134	0	0	0	0
IVN	129	0	0	0	0
NCX	204	0	0	0	0
NG	51	0	0	0	0
NT	1245	2	0.16%	0	0
NXY	682	0	0	2	0.29%
POT	1582	0	0	1	0.06%
RY	735	0	0	0	0
SLF	36	0	0	0	0
SLW	657	0	0	0	0
SU	1872	0	0	0	0
TCK	1782	0	0	1	0.05%
TD	630	0	0	0	0
THI	57	0	0	0	0
TLM	1125	0	0	0	0
TOC	21	0	0	0	0
Arithmetic average			0		0
Total	19480	2		4	
Weighted average			0.01%		0.02%

Table 5 Panel B: Arbitrage existing in cross-listed US sample generated from violations of cross-border put-call parity

This table displays the arbitrage existing in cross-listed US sample obtained from Inequality (5.4) and (5.5). Arithmetic average and observation weighted average of arbitrage percentage values generated from cross-border put-call parity are given in this table. All information is listed by firm.

Symbol	obs	arbi4	arbi4(%)	arbi5	arbi5(%)
ABX	1731	1	0.06%	12	0.69%
AEM	1198	3	0.25%	15	1.25%
AGU	775	0	0	2	0.26%
BCE	112	0	0	0	0
BVF	431	14	3.25%	1	0.23%
CLS	25	0	0	0	0
CNQ	1538	3	0.20%	3	0.20%
CP	230	1	0.43%	3	1.30%
ECA	1985	6	0.30%	16	0.81%
ENB	15	0	0	0	0
ERF	117	0	0	0	0
FDG	374	0	0	3	0.80%
FFH	7	0	0	0	0
IMO	134	0	0	1	0.75%
IVN	129	0	0	0	0
NCX	204	3	1.47%	1	0.49%
NG	51	0	0	0	0
NT	1245	0	0	2	0.16%
NXY	682	0	0	16	2.35%
POT	1582	2	0.13%	29	1.83%
RY	735	0	0	0	0
SLF	36	0	0	0	0
SLW	657	0	0	1	0.15%
SU	1872	2	0.11%	21	1.12%
TCK	1782	0	0	18	1.01%
TD	630	0	0	0	0
THI	57	0	0	0	0
TLM	1125	0	0	9	0.80%
TOC	21	0	0	0	0
Arithmetic average			0.21%		0.50%
Total	19480	35		153	
Weighted average			0.18%		0.78%

Table 6: Arbitrage existing in pure US sample generated from violations of domestic put-call

This table displays the arbitrage existing in control US sample obtained from Inequality (5.2) and (5.3). Arithmetic average and observation weighted average of arbitrage percentage values generated from domestic put-call parity are given in this table. All information is listed by firm.

Symbol	obs	arbi2	arbi2(%)	arbi3	aibi3(%)
ACI	1387	0	0	0	0
ALJ	472	0	0	0	0
ARD	524	0	0	1	0.19%
ASF	500	0	0	0	0
ASH	484	0	0	1	0.21%
BBG	163	0	0	0	0
BBT	836	0	0	0	0
BEZ	40	0	0	0	0
BTE	80	0	0	0	0
CCC	90	0	0	0	0
CHK	1561	0	0	0	0
CLF	1353	0	0	0	0
CSX	1385	0	0	0	0
CTL	151	0	0	0	0
CVX	1723	0	0	0	0
EGN	60	0	0	0	0
EIG	5	0	0	0	0
GG	1600	0	0	0	0
HUN	311	0	0	0	0
KEY	630	0	0	0	0
KGC	1185	2	0.17%	0	0
LLY	1259	0	0	0	0
MCD	1673	0	0	0	0
NWN	10	0	0	0	0
PCU	1732	0	0	0	0
SFG	31	0	0	0	0
SWC	641	0	0	0	0
TNS	5	0	0	0	0
USU	1235	0	0	0	0
Arithmetic average			0.01%		0.01%
Total	21126	2		2	
Weighted average			0.01%		0.01%

Table 7 Arbitrage opportunities sorted by date

Panel A: Arbitrage opportunities reported by date in inter-listed Canadian sample

This table displays the arbitrage existing in all three samples obtained from Inequality (5.2), (5.3), (5.4) and (5.5). All arbitrage opportunities are reported by date. In Panel A, * denotes the special day March 14th, 2007. Put-call parity was violated in most of the observations that day, whereas arbitrage opportunities occurred occasionally in other days.

Date	Obs	arbi2	arbi2(%)	arbi3	arbi3(%)	arbi4	arbi4(%)	arbi5	arbi5(%)
1/3/2007	141	1	0.71%	0	0	1	0.71%	0	0
1/5/2007	130	2	1.54%	0	0	0	0	0	0
1/8/2007	101	1	0.99%	0	0	0	0	0	0
1/12/2007	102	1	0.98%	0	0	0	0	0	0
1/16/2007	99	1	1.01%	0	0	0	0	0	0
1/31/2007	85	0	0	1	1.18%	0	0	0	0
2/27/2007	142	0	0	1	0.70%	0	0	0	0
3/14/2007*	88	26	29.55%	13	14.77%	16	18.18%	9	10.23%
3/15/2007	73	0	0	6	8.22%	0	0	6	8.22%
3/19/2007	94	0	0	5	5.32%	0	0	0	0
5/3/2007	120	0	0	0	0	2	1.67%	0	0
5/11/2007	114	0	0	0	0	4	3.51%	0	0
5/14/2007	103	0	0	0	0	2	1.94%	0	0
5/15/2007	95	0	0	1	1.05%	6	6.32%	0	0
5/18/2007	117	1	0.85%	0	0	0	0	0	0
5/23/2007	90	1	1.11%	0	0	0	0	0	0
6/11/2007	78	0	0	1	1.28%	0	0	0	0
7/3/2007	89	0	0	1	1.12%	0	0	0	0
7/9/2007	81	0	0	1	1.23%	0	0	0	0
7/23/2007	132	0	0	5	3.79%	0	0	1	0.76%
7/24/2007	185	0	0	3	1.62%	0	0	0	0
7/26/2007	156	0	0	1	0.64%	0	0	0	0
7/30/2007	160	1	0.63%	0	0	1	0.63%	0	0
7/31/2007	161	0	0	1	0.62%	0	0	0	0
8/13/2007	117	0	0	1	0.85%	0	0	0	0
10/15/2007	156	0	0	1	0.64%	0	0	0	0
10/30/2007	204	0	0	1	0.49%	0	0	0	0
11/6/2007	200	0	0	1	0.50%	0	0	0	0
12/19/2007	131	0	0	1	0.76%	0	0	0	0
12/20/2007	117	0	0	1	0.85%	0	0	0	0
12/24/2007	130	0	0	1	0.77%	0	0	0	0
12/28/2007	166	0	0	2	1.20%	0	0	0	0

Table 7 Panel B: Arbitrage opportunities reported by date in inter-listed U.S. sample

Date	Obs	arbi2	arbi3	arbi4	arbi5	Date	Obs	arbi2	arbi3	arbi4	arbi5
1/3/2007	129	0	0	0	2	5/4/2007	98	0	0	0	7
1/5/2007	117	0	0	0	3	5/8/2007	82	0	0	1	4
1/16/2007	78	0	0	0	1	5/11/2007	87	0	1	1	0
1/17/2007	62	0	0	1	0	5/14/2007	73	0	0	1	4
1/19/2007	68	0	0	0	1	5/15/2007	61	0	0	0	5
1/22/2007	68	0	0	0	2	5/16/2007	83	0	1	1	1
1/24/2007	95	0	1	0	1	5/17/2007	93	0	0	0	2
1/26/2007	80	0	0	0	1	5/18/2007	82	0	0	0	3
1/29/2007	65	0	0	0	1	5/22/2007	103	0	0	0	2
2/1/2007	65	0	0	0	1	5/24/2007	115	0	0	0	3
2/5/2007	62	0	0	0	1	5/25/2007	79	0	0	0	3
2/6/2007	69	0	0	0	1	6/4/2007	63	0	0	0	1
2/12/2007	64	0	0	0	2	6/7/2007	87	0	0	0	1
2/20/2007	88	0	0	0	1	6/11/2007	55	0	0	0	3
2/22/2007	68	0	0	0	1	6/12/2007	71	0	0	0	2
2/23/2007	50	0	0	0	1	6/13/2007	67	0	0	0	2
2/26/2007	56	0	0	0	1	6/14/2007	90	0	0	1	0
2/27/2007	108	0	0	0	2	6/15/2007	79	0	0	0	1
2/28/2007	75	0	0	0	1	6/19/2007	61	0	0	0	2
3/1/2007	80	0	0	0	2	6/22/2007	54	0	0	0	2
3/5/2007	70	0	0	0	3	6/25/2007	57	0	0	0	3
3/6/2007	75	0	0	0	1	6/26/2007	80	0	0	0	2
3/7/2007	79	0	0	0	1	6/29/2007	35	0	0	3	1
3/13/2007	71	0	0	0	5	7/3/2007	64	0	0	2	6
3/15/2007	61	0	0	0	1	7/5/2007	73	0	1	0	4
3/16/2007	58	0	0	0	3	7/9/2007	58	0	0	0	1
3/19/2007	76	0	0	0	6	7/12/2007	79	0	0	0	1
3/22/2007	90	0	0	1	3	7/19/2007	92	0	0	1	3
3/26/2007	76	0	0	0	1	7/26/2007	139	0	0	5	3
3/28/2007	69	0	0	0	1	7/27/2007	83	0	0	0	3
4/5/2007	66	0	0	0	1	7/31/2007	108	0	0	0	5
4/18/2007	66	0	0	2	0	8/1/2007	102	1	0	5	0
4/19/2007	88	0	0	2	0	8/9/2007	101	0	0	0	4
4/23/2007	73	0	0	1	0	8/21/2007	62	1	0	0	0
4/24/2007	81	0	0	1	0	9/5/2007	77	0	0	0	1
4/26/2007	66	0	0	0	2	9/20/2007	114	0	0	0	1
4/27/2007	77	0	0	1	0	11/8/2007	128	0	0	1	0
4/30/2007	75	0	0	1	0	11/14/2007	95	0	0	1	0
5/1/2007	68	0	0	0	4	11/23/2007	55	0	0	0	6
5/3/2007	81	0	0	0	3	12/12/2007	68	0	0	2	0

Table 7 Panel C: Arbitrage opportunities reported by date in purely U.S. sample

Date	Obs	arbi2	arbi3	arbi2(%)	arbi3(%)
1/23/2007	86	0	1	0	0
3/5/2007	85	1	0	1.18%	0.01%
4/25/2007	89	1	0	1.12%	0.01%
11/2/2007	109	0	1	0	0
Total		2	2		

Table 8: Intra-day price drops of some Canadian leading companies on March 13th, 2007

This table displays the intraday price drops of eight Canadian leading companies. These prices downwards happened on March 13th, 2007 are obtained in both Canadian and the U.S. markets. Decimal values and percentages are given in this table.

Symbol	Company name	Drop in Canadian Market	Drop in the U.S. market
ABX	Barrick Gold Corp.	C$1.1 (3%)	$0.685 (2%)
ECA	EnCana Corp.	C$0.73 (1.3%)	$0.81 (1.7%)
NT	Nortel Networks Corp.	C$1.51 (4%)	$1.2 (4%)
RY	Royal Bank of Canada	C$0.92 (1.6%)	$0.9 (1.8%)
SU	Suncor Energy Inc.	C$2 (2.5%)	$1.8 (2.6%)
TCK	Teck Comino Limited	C$0.505 (0.6%)	$1.43 (1.9%)
TD	Toronto-Dominion Bank	C$1.2 (1.7%)	$0.68 (1.1%)
TLM	Talisman Energy Inc.	C$0.35 (1.8%)	$0.3 (1.9%)

Table 9: Price changes and co-movement on March 14th, 2007 in both the Canadian and the US

This table presents the intraday price movement of 29 cross-border listed companies on March 14th, 2007. If the price movements in Canadian market are opposite with that of the U.S. market, we consider the co-movement of the two markets as negative (-).The symbol * denotes that the security prices of that firm violated put-call parity that day.

Symbol	Price change in CA (%)	Price change in US (%)	Co-movement
ABX	0.8	-2.4	−
AEM	1.49	0.93	+
AGU	0.2	0.05	+
BCE	-0.1	-0.31	+
BVF	0.61	0.49	+
CLS	1.4	0.5	+
CNQ*	1.03	-0.12	−
CP	0.87	0.58	+
ECA*	1.04	-0.84	−
ENB	0.11	-0.25	−
ERF	-0.52	-0.56	+
FDG	-0.45	-0.88	+
FFH	1.07	3.55	+
IMO	-1.18	-1.03	+
IVN	-1.34	-2.67	+
NCX*	-0.82	-1.03	+
NG	1.3	0.12	+
NT*	0.99	-3.13	−
NXY*	1.22	0.95	+
POT*	0.77	0.51	+
RY*	-0.12	0.31	−
SLF	-1.2	-1.32	+
SLW*	2.44	2.21	+
SU*	-0.08	2.4	−
TCK*	0.18	-1.54	−
TD*	-0.94	0.4	−
THI	0.06	0.13	+
TLM*	0.58	-1.7	−
TOC*	0.77	-0.07	−

The symbol * denotes that the security prices of that firm violated put-call parity on March 14th, 2007.

Table 10: One sided-test: Paired trading volume for options for means

Panel A: One sided-test: Paired trading volume for call options for means

Table 10 Panel A presents the results of mean-variance tests on option trading volume of the two countries. Average trading volume per option in Canada is compared to its counterpart in the U.S. market, firm by firm.

	C_volume in CA	*C_volume in US*
Mean	58.4549	206.741
Variance	995.234	35040.2
Observations	29	29
Hypothesized Mean Difference	0	
df	28	
t_Stat	-4.4404	
P-value	6.4E-05	
t Critical at 99%	2.4671	

H_0: C_volume in CA ≥ C_volume in US
Ha: C_volume in CA < C_volume in US
As t_Stat < -t_Ctitical
We reject H_0 for a 99% confidence interval.

Thus, we can get the conclusion that the trading volume of call in Canadian option markets are significantly less than the trading volume of call in the U.S. option markets.

Table 10 Panel B: One-sided test: Paired trading volume for put options for means

	P_volume in CA	*P_volume in US*
Mean	45.52729357	118.4644512
Variance	1019.154195	11439.3188
Observations	29	29
Hypothesized Mean Difference	0	
df	28	
t_Stat	-3.805300564	
P-value	0.000353242	
t Critical at 99%	2.467140089	

H_0: P_volume in CA ≥ P_volume in US
Ha: P_volume in CA < P_volume in US
As t_Stat < -t_Ctitical
We reject H_0 for a 99% confidence interval.

Thus, we can get the conclusion that the trading volume of put in Canadian option markets are significantly less than the trading volume of put in the U.S. option markets.

Table 11: One-sided test: Comparison between option trading volume in dramatic market price drops and normal monthly average

Table 11 shows the details of mean-variance tests on option trading volume in sudden and dramatic market price drops. Average daily trading volume during the sharp price drops in Canadian market is compared to its corresponding monthly average.

	Trading volume in dramatic price drops	Monthly average trading volume
Mean	4200.71	5586.63
Variance	1298423	608431
Observations	10	10
Pearson Correlation	0.88592	
Hypothesized Mean Difference	0	
df	9	
t Stat	-7.6062	
P-value	1.7E-05	
t Critical at 99%	2.82144	

H_0: Trading volume in dramatic price drops ≥ Monthly average trading volume.
Ha: Trading volume in dramatic price drops < Monthly average trading volume.
As t_Stat <-t_Ctitical
We reject H_0 for a 99% confidence interval.

Thus, we can get the conclusion that the option trading volume in dramatic price drops are less than corresponding monthly average.

Table 12: Summary statistics for option pairs in three samples (Full sample)

This table displays the summary statistics of maturity and option trading volume, for the two cross-border listed full samples and one control full sample.

	Cross-listed Canadian			Cross-listed US			Pure US		
	Maturity	Volume_C	Volume_P	Maturity	Volume_C	Volume_P	Maturity	Volume_C	Volume_P
Mean	66.561	52.4389	35.8087	65.6443	232.196	143.237	67.1801	435.918	229.794
Maximum	178	7410	4507	178	95156	30153	178	708542	27981
Minimum	1	1	1	1	1	1	1	1	1
Median	50	20	16	51	54	32	51	76	46
S.D.	50.2499	152.045	95.1725	49.0669	921.739	509.478	50.0733	4949.36	765.043
Skewness	0.6302	16.2518	18.3404	0.6723	42.0222	18.3349	0.6395	93.733	11.9713
Kurtosis	-0.8607	446.379	531.226	-0.7364	3476.47	642.109	-0.8028	11860.4	228.944
N	30625	30625	30625	35854	35854	35854	37838	37838	37838

Table 13: Arbitrage existing in cross-listed Canadian sample generated from violations of

put-call parity (Full sample)

Panel A: Arbitrage existing in cross-listed Canadian sample generated from violations of domestic put-call parity (Full sample)

This table displays the arbitrage existing in cross-listed Canadian full sample obtained from Inequality (5.2) and (5.3). Arithmetic average and observation weighted average of arbitrage percentage values generated from domestic put-call parity are given in this table. All information is listed by firm.

Symbol	obs	arbi2	arbi2(%)	arbi3	arbi3(%)
ABX	3090	2	0.06%	1	0.03%
AEM	1979	0	0	0	0
AGU	1057	0	0	0	0
BCE	113	0	0	5	4.42%
BVF	539	0	0	6	1.11%
CLS	26	0	0	1	3.85%
CNQ	1967	5	0.25%	0	0
CP	268	0	0	0	0
ECA	2241	2	0.09%	4	0.18%
ENB	15	0	0	0	0
ERF	149	0	0	5	3.36%
FDG	530	0	0	0	0
FFH	7	0	0	0	0
IMO	137	0	0	0	0
IVN	144	0	0	0	0
NCX	221	0	0	1	0.45%
NG	85	0	0	0	0
NT	1403	6	0.43%	1	0.07%
NXY	766	3	0.39%	5	0.65%
POT	6627	1	0.02%	2	0.03%
RY	736	8	1.09%	9	1.22%
SLF	36	0	0	0	0
SLW	830	5	0.60%	0	0
SU	3972	2	0.05%	1	0.03%
TCK	1804	5	0.28%	18	1.00%
TD	632	1	0.16%	0	0
THI	57	0	0	0	0
TLM	1172	1	0.09%	4	0.34%
TOC	22	0	0	0	0
Arithmetic average			0.18%		0.58%
Total	30625	41		63	
Weighted average		0.32%			0.31%

Table 13 Panel B : Arbitrage existing in cross-listed Canadian sample generated from violations of cross-border put-call parity (Full sample)

This table displays the arbitrage existing in cross-listed Canadian full sample obtained from Inequality (5.4) and (5.5). Arithmetic average and observation weighted average of arbitrage percentage values generated from cross-border put-call parity are given in this table. All information is listed by firm.

Symbol	obs	arbi4	arbi4(%)	arbi5	arbi5(%)
ABX	3090	0	0	0	0
AEM	1979	0	0	0	0
AGU	1057	0	0	0	0
BCE	113	0	0	0	0
BVF	539	0	0	6	1.11%
CLS	26	0	0	0	0
CNQ	1967	1	0.05%	0	0
CP	268	0	0	0	0
ECA	2241	2	0.09%	3	0.13%
ENB	15	0	0	0	0
ERF	149	0	0	5	3.36%
FDG	530	0	0	0	0
FFH	7	0	0	0	0
IMO	137	0	0	0	0
IVN	144	0	0	0	0
NCX	221	0	0	0	0
NG	85	0	0	0	0
NT	1403	6	0.43%	0	0
NXY	766	15	1.96%	0	0
POT	6627	0	0	0	0
RY	736	2	0.27%	3	0.41%
SLF	36	0	0	0	0
SLW	830	5	0.60%	0	0
SU	3972	1	0.03%	1	0.03%
TCK	1804	7	0.39%	7	0.39%
TD	632	0	0	0	0
THI	57	0	0	0	0
TLM	1172	0	0	1	0.09%
TOC	22	0	0	0	0
Arithmetic average			0.13%		0.19%
Total	30625	39		26	
Weighted average		0.13%			0.08%

Table 14: Arbitrage existing in cross-listed US sample generated from violations of put-call parity (Full sample)

Panel A: Arbitrage existing in cross-listed US sample generated from violations of domestic put-call parity (Full sample)

This table displays the arbitrage existing in cross-listed US full sample obtained from Inequality (5.2) and (5.3). Arithmetic average and observation weighted average of arbitrage percentage values generated from domestic put-call parity are given in this table. All information is listed by firm.

Symbol	obs	arbi2	arbi2(%)	arbi3	arbi3(%)
ABX	3226	0	0	0	0
AEM	2531	0	0	0	0
AGU	1334	0	0	0	0
BCE	258	0	0	0	0
BVF	972	1	0.10%	0	0
CLS	78	0	0	0	0
CNQ	1986	0	0	0	0
CP	456	0	0	0	0
ECA	2078	0	0	0	0
ENB	36	0	0	0	0
ERF	1263	0	0	0	0
FDG	1686	0	0	0	0
FFH	268	0	0	0	0
IMO	185	0	0	0	0
IVN	512	0	0	0	0
NCX	379	0	0	0	0
NG	783	0	0	0	0
NT	1379	2	0.15%	0	0
NXY	810	0	0	2	0.25%
POT	7369	0	0	2	0.03%
RY	272	0	0	0	0
SLF	20	0	0	0	0
SLW	1533	0	0	0	0
SU	4145	0	0	0	0
TCK	905	0	0	1	0.11%
TD	291	0	0	0	0
THI	136	0	0	2	1.47%
TLM	936	0	0	0	0
TOC	27	0	0	0	0
Arithmetic average			0.01%		0.06%
Total	35854	3		7	
Weighted average		0.01%			0.02%

Table 14 Panel B: Arbitrage existing in cross-listed US sample generated from violations of cross-border put-call parity (Full sample)

This table displays the arbitrage existing in cross-listed US full sample obtained from Inequality (5.4) and (5.5). Arithmetic average and observation weighted average of arbitrage percentage values generated from cross-border put-call parity are given in this table. All information is listed by firm.

Symbol	obs	arbi4	arbi4(%)	arbi5	arbi5(%)
ABX	3226	1	0.03%	18	0.56%
AEM	2531	4	0.16%	19	0.75%
AGU	1334	1	0.07%	4	0.30%
BCE	258	0	0	0	0
BVF	972	17	1.75%	1	0.10%
CLS	78	0	0	0	0
CNQ	1986	4	0.20%	5	0.25%
CP	456	0	0	6	1.32%
ECA	2078	7	0.34%	17	0.82%
ENB	36	0	0	0	0
ERF	1263	0	0	0	0
FDG	1686	0	0	3	0.18%
FFH	268	0	0	0	0
IMO	185	0	0	1	0.54%
IVN	512	0	0	0	0
NCX	379	3	0.79%	1	0.26%
NG	783	0	0	0	0
NT	1379	0	0	3	0.22%
NXY	810	0	0	20	2.47%
POT	7369	1	0.01%	88	1.19%
RY	272	0	0	0	0
SLF	20	0	0	0	0
SLW	1533	0	0	1	0.07%
SU	4145	3	0.07%	39	0.94%
TCK	905	0	0	24	2.65%
TD	291	0	0	0	0
THI	136	0	0	0	0
TLM	936	0	0	10	1.07%
TOC	27	0	0	0	0
Arithmetic average			0.12%		0.47%
Total	35854	41		260	
Weighted average		0.11%			0.73%

Table 15: Arbitrage existing in pure US sample generated from violations of domestic put-call parity (Full sample)

This table displays the arbitrage existing in control US full sample obtained from Inequality (5.2) and (5.3). Arithmetic average and observation weighted average of arbitrage percentage values generated from domestic put-call parity are given in this table. All information is listed by firm.

Symbol	obs	arbi2	arbi2(%)	arbi3	aibi3(%)
ACI	2198	0	0	0	0
ALJ	545	0	0	0	0
ARD	628	0	0	1	0.16%
ASF	550	0	0	0	0
ASH	545	0	0	1	0.18%
BBG	168	0	0	0	0
BBT	1056	0	0	0	0
BEZ	41	0	0	0	0
BTE	82	0	0	0	0
CCC	91	0	0	0	0
CHK	2961	0	0	0	0
CLF	2886	0	0	0	0
CSX	1962	0	0	0	0
CTL	152	0	0	0	0
CVX	3967	0	0	0	0
EGN	67	0	0	0	0
EIG	5	0	0	0	0
GG	3644	0	0	2	0.05%
HUN	357	0	0	0	0
KEY	780	0	0	0	0
KGC	1504	4	0.27%	0	0
LLY	1544	0	0	0	0
MCD	3443	0	0	1	0.03%
NWN	10	0	0	0	0
PCU	6012	0	0	0	0
SFG	31	0	0	0	0
SWC	699	0	0	0	0
TNS	5	0	0	0	0
USU	1905	0	0	0	0
Arithmetic average			0.01%		0.01%
Total	37838	4		5	
Weighted average		0			0

Table 16: Arbitrage opportunities reported by date (Full sample)

Panel A: Arbitrage opportunities reported by date in inter-listed Canadian sample (Full sample)

Date	Obs	arbi2	arbi3	arbi4	arbi5
1/3/2007	166	1	0	1	0
1/5/2007	148	2	0	0	0
1/8/2007	102	1	0	0	0
1/12/2007	114	1	0	0	0
1/16/2007	105	1	0	0	0
1/31/2007	89	0	1	0	0
2/14/2007	111	1	0	1	0
2/16/2007	95	1	0	1	0
2/27/2007	151	1	1	1	0
3/14/2007*	100	29	21	19	15
3/15/2007	82	0	6	0	6
3/19/2007	101	0	5	0	0
5/3/2007	125	0	0	3	0
5/11/2007	124	0	0	4	0
5/14/2007	108	0	0	2	0
5/15/2007	96	0	1	6	0
5/18/2007	120	1	0	0	0
5/23/2007	101	1	0	0	0
6/11/2007	83	0	1	0	0
7/3/2007	93	0	1	0	0
7/9/2007	81	0	1	0	0
7/23/2007	136	0	5	0	5
7/24/2007	198	0	4	0	0
7/26/2007	181	0	1	0	0
7/30/2007	174	1	1	1	0
7/31/2007	168	0	1	0	0
8/9/2007	143	0	1	0	0
8/13/2007	124	0	1	0	0
8/16/2007	267	0	1	0	0
10/15/2007	159	0	1	0	0
10/30/2007	208	0	1	0	0
11/6/2007	206	0	1	0	0
11/19/2007	186	0	1	0	0
12/19/2007	142	0	1	0	0
12/20/2007	130	0	1	0	0
12/24/2007	132	0	1	0	0
12/27/2007	190	0	1	0	0
12/28/2007	169	0	2	0	0

Table 16 Panel B: Arbitrage opportunities reported by date in inter-listed US sample (Full sample)

Date	Obs	arbi2	arbi3	arbi4	arbi5	Date	Obs	arbi2	arbi3	arbi4	arbi5
1/3/2007	166	0	0	0	2	5/4/2007	120	0	0	0	7
1/5/2007	148	0	0	0	4	5/8/2007	117	0	0	1	5
1/16/2007	105	0	0	0	1	5/11/2007	124	0	2	1	0
1/17/2007	80	0	0	1	0	5/14/2007	108	0	0	1	4
1/19/2007	87	0	0	0	1	5/15/2007	96	0	0	0	6
1/22/2007	96	0	0	0	8	5/16/2007	122	0	1	1	1
1/23/2007	142	0	0	0	2	5/17/2007	127	0	0	0	3
1/24/2007	115	1	1	0	1	5/18/2007	120	0	0	0	15
1/26/2007	107	0	0	0	1	5/22/2007	131	0	0	0	3
1/29/2007	99	0	0	0	3	5/24/2007	146	0	0	0	5
1/30/2007	94	0	0	0	2	5/25/2007	109	0	0	0	5
1/31/2007	89	0	0	0	1	5/31/2007	118	0	1	0	1
2/1/2007	98	0	0	0	5	6/4/2007	98	0	0	0	2
2/5/2007	87	0	0	0	1	6/7/2007	129	0	0	0	1
2/6/2007	93	0	0	0	3	6/11/2007	83	0	0	0	4
2/7/2007	98	0	0	0	1	6/12/2007	99	0	0	0	2
2/9/2007	102	0	0	0	1	6/13/2007	95	0	0	0	2
2/12/2007	78	0	0	0	2	6/14/2007	120	0	0	1	0
2/13/2007	96	0	0	0	2	6/15/2007	106	0	0	0	1
2/20/2007	138	0	0	0	1	6/19/2007	101	0	0	0	4
2/21/2007	113	0	0	0	1	6/21/2007	84	0	0	1	0
2/22/2007	106	0	0	0	5	6/22/2007	80	0	0	0	4
2/23/2007	65	0	0	0	1	6/25/2007	82	0	0	0	3
2/26/2007	78	0	0	0	1	6/26/2007	95	0	0	0	3
2/27/2007	151	0	0	0	2	6/27/2007	105	0	1	0	1
2/28/2007	101	0	0	0	1	6/28/2007	61	0	0	0	1
3/1/2007	104	0	0	0	2	6/29/2007	44	0	0	4	1
3/2/2007	123	0	0	0	2	7/3/2007	93	0	0	0	9
3/5/2007	92	0	0	0	3	7/5/2007	107	0	1	0	4
3/6/2007	105	0	0	0	1	7/9/2007	81	0	0	0	1
3/7/2007	113	0	0	0	1	7/12/2007	102	0	0	0	1
3/13/2007	98	0	0	0	7	7/19/2007	127	0	0	0	6
3/15/2007	82	0	0	0	1	7/20/2007	127	0	0	0	1
3/16/2007	76	0	0	0	3	7/26/2007	181	0	0	6	6
3/19/2007	101	0	0	1	8	7/27/2007	112	0	0	0	4
3/22/2007	110	0	0	1	4	7/31/2007	168	0	0	0	10
3/26/2007	93	0	0	0	1	8/1/2007	166	1	0	6	0
3/28/2007	91	0	0	0	4	8/9/2007	143	0	0	0	7
4/2/2007	93	0	0	1	0	8/21/2007	91	1	0	0	0
4/5/2007	106	0	0	0	1	9/5/2007	117	0	0	0	1
4/9/2007	110	0	0	0	1	9/20/2007	192	0	0	0	1
4/11/2007	101	0	0	0	2	10/30/2007	208	0	0	0	1
4/18/2007	114	0	0	2	0	11/8/2007	243	0	0	1	0
4/19/2007	121	0	0	2	0	11/13/2007	219	0	0	0	1
4/23/2007	115	0	0	2	0	11/14/2007	167	0	0	1	0
4/24/2007	112	0	0	1	0	11/23/2007	80	0	0	0	6
4/26/2007	111	0	0	0	6	12/12/2007	133	0	0	3	0
4/27/2007	108	0	0	1	0	12/21/2007	150	0	0	0	1
4/30/2007	111	0	0	1	1	12/24/2007	132	0	0	1	0
5/1/2007	101	0	0	0	8	12/27/2007	190	0	0	0	2
5/3/2007	125	0	0	0	5						

Table 16 Panel C: Arbitrage opportunities reported by date in purely US sample (Full sample)

Date	Obs	arbi2	arbi3	arbi2(%)	arbi3(%)
1/23/2007	135	0	1	0	0.74%
2/14/2007	112	0	1	0	0.89%
3/5/2007	134	1	0	0.75%	0
3/8/2007	103	1	0	0.97%	0
3/14/2007	99	1	0	1.01%	0
4/25/2007	148	1	0	0.68%	0
5/15/2007	145	0	1	0	0.69%
5/16/2007	145	0	1	0	0.69%
11/2/2007	238	0	1	0	0.42%
Total		4	5		

This table displays the arbitrage existing in all three full samples obtained from Inequality (5.2), (5.3), (5.4) and (5.5). All arbitrage opportunities are reported by date. In Panel A, * denotes the special day March 14th, 2007. Put-call parity was violated in most of the observations that day, whereas arbitrage opportunities occurred occasionally in other days.

Figure 1: S&P 500 daily closing prices in 2007

This figure displays the S&P 500 price movements in 2007. Closing prices are adopted in this figure.

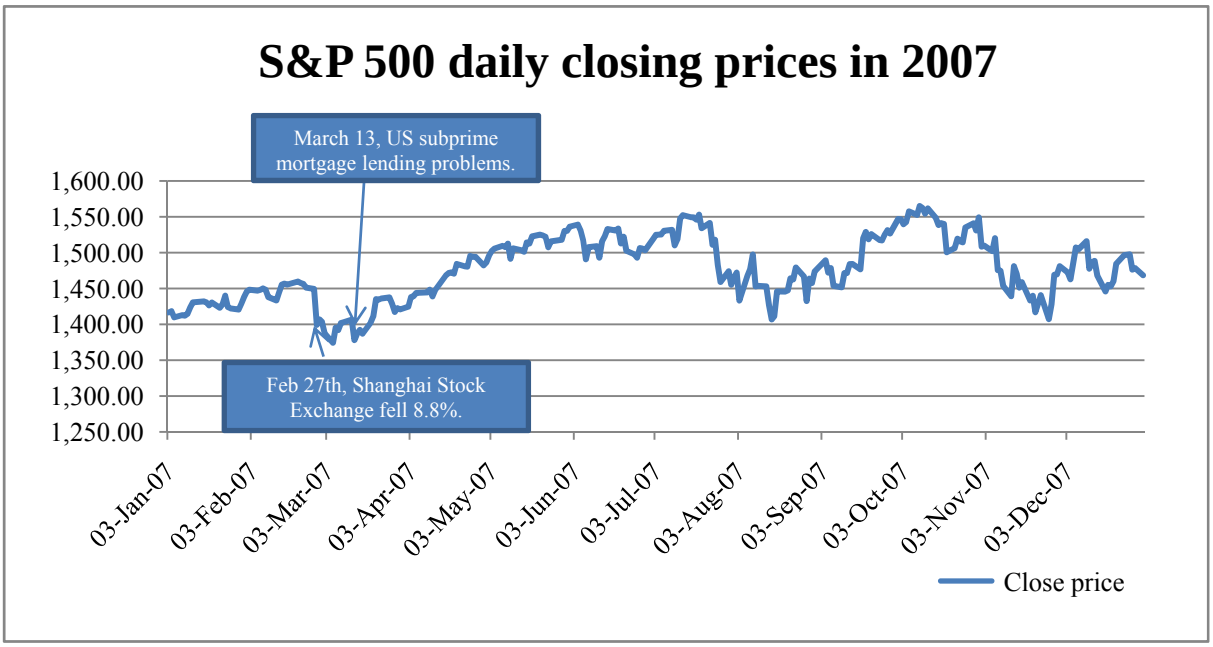
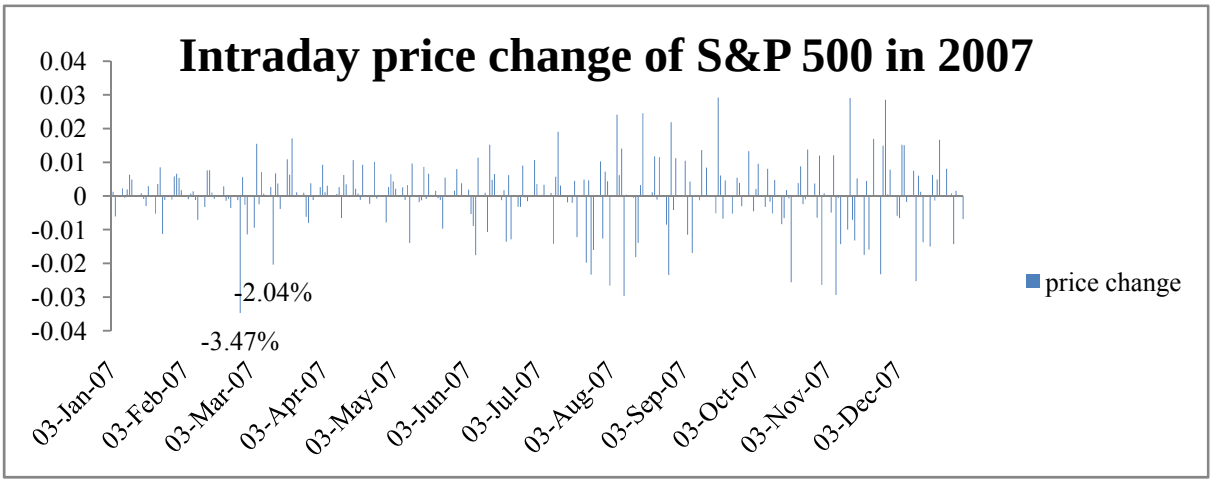


Figure 2: Intraday price changes of S&P 500 and S&P/TSX in 2007

The first figure displays the S&P 500 intraday price changes in 2007. Closing prices are adopted in this figure. The lines above x-axis represent price increase, whereas lines below x-axis stand for price drops.



The second figure displays the S&P/TSX intraday price changes in 2007. Closing prices are adopted in this figure. The lines above x-axis represent price increase, whereas lines below x-axis stand for price drops.

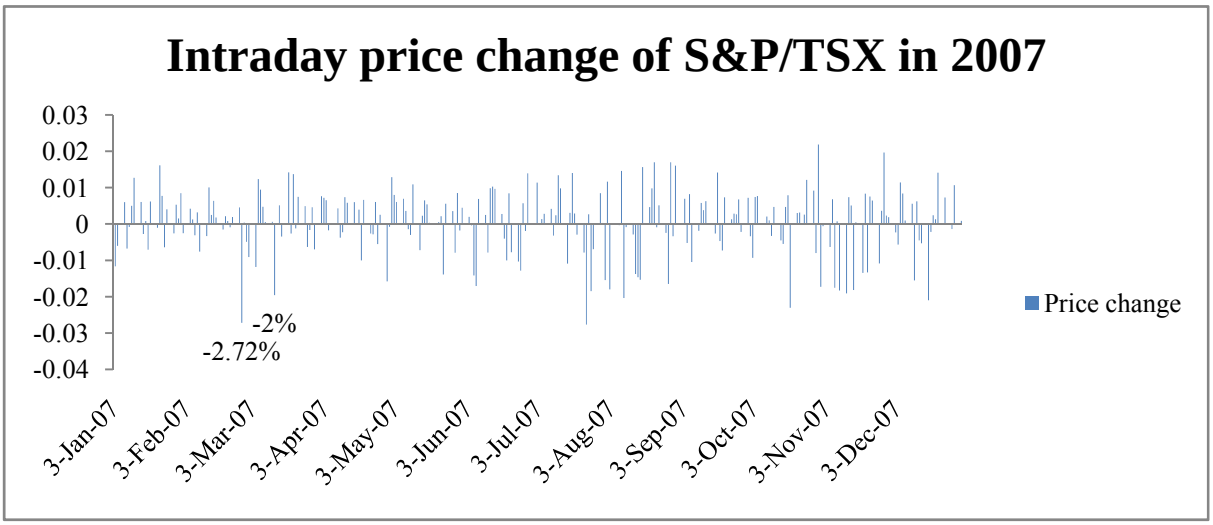
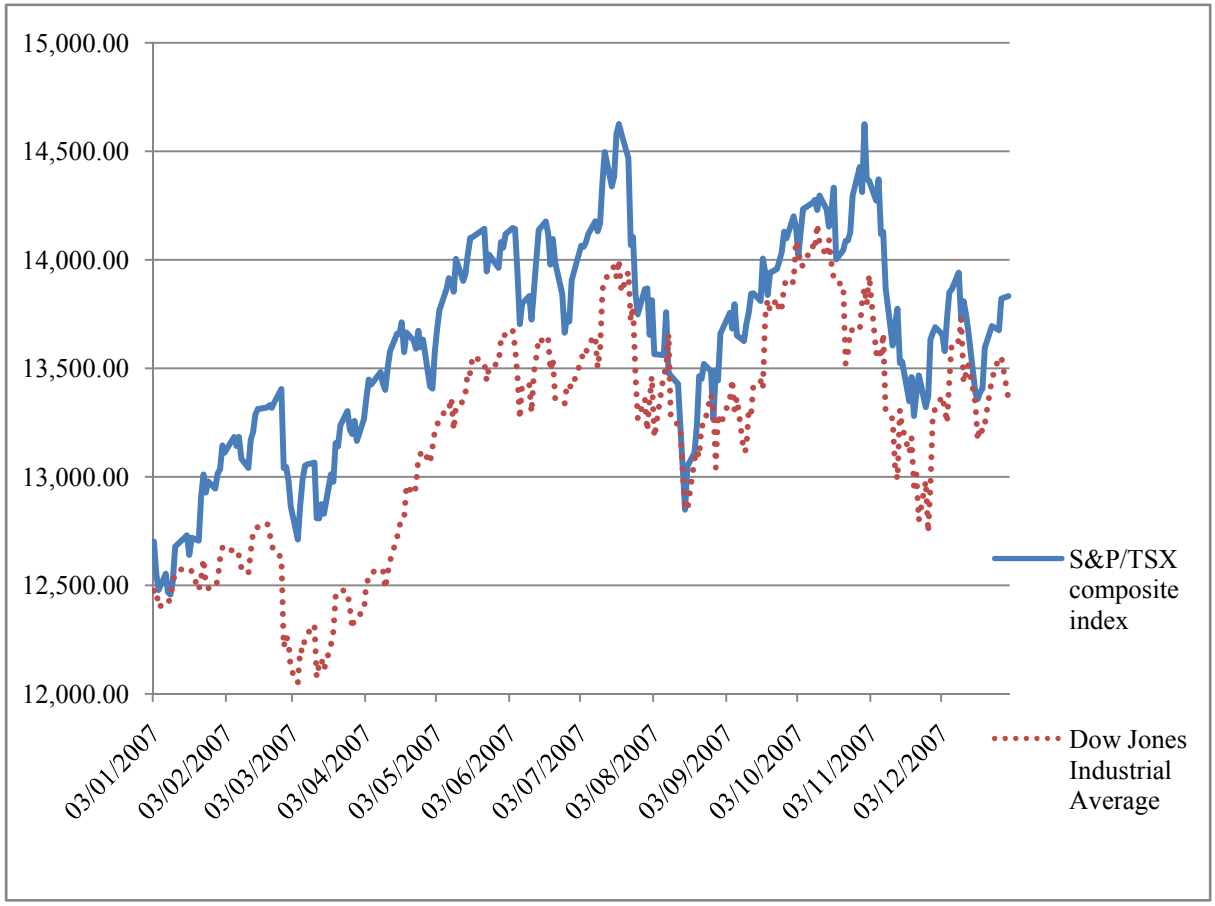


Figure 3: Price movements of the S&P/TSX composite index and the Dow Jones industrial average

Figure 3 displays the daily quotes of the S&P /TSX and the Dow Jones industrial average in 2007. The figure shows that the patterns of the two indices are similar. The results of coin-tegration tests follow the figure.



ADF test for stationary of Dow Jones closing price

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Single Mean	0	-7.6037	0.2353	-2.08	0.2519	2.25	0.4969
	1	-6.1722	0.3306	-1.89	0.3368	1.9	0.5876
	2	-6.2216	0.3268	-1.92	0.3211	1.99	0.5641
	3	-7.8636	0.2209	-2.1	0.2444	2.31	0.4832

Philips-Perron test for stationarity of 1-differenced Dow Jones closing price

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau
Single mean	0	-278.5	0.0001***	-17.81	<.0001***
	1	-278.09	0.0001***	-17.82	<.0001***
	2	-277.11	0.0001***	-17.83	<.0001***

ADF test for stationary of S&P/TSX closing price

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Single Mean	0	-9.4947	0.1487	-2.43	0.1345	3.13	0.2728
	1	-9.3044	0.1557	-2.51	0.115	3.41	0.2032
	2	-11.099	0.1002	-2.74	0.0693*	4.02	0.087*
	3	-13.167	0.0598*	-2.84	0.0544*	4.25	0.0733*

Philips-Perron test for stationarity of 1-differenced S&P/TSX closing price

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau
Single mean	0	-264.26	0.0001***	-16.88	<.0001***
	1	-264.38	0.0001***	-16.88	<.0001***
	2	-270.49	0.0001***	-16.85	<.0001***

ADF test for stationary of residual of Dow Jones and S&P/TSX

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Single mean	0	-16.351	0.0266	-2.92	0.0447	4.3	0.0702*
	1	-16.962	0.0227	-3	0.0368	4.56	0.054*
	2	-14.948	0.038	-2.78	0.0626	3.94	0.092*
	3	-16.67	0.0244	-2.86	0.0524	4.14	0.0798*

* Denotes rejection of the hypothesis at 5% significance level.

***Denotes rejection of the hypothesis at 1% significance level.

Rho stands for the coefficient of a lagged dependent variable.

Tau denotes the calculated t value.

Figure 4: Distribution of arbitrage reported on March 14th, 2007

This figure presents the distribution of opportunities for arbitrage on March 14th. There were total 12 firms reported arbitrage that day, 7 of them are well known leading companies in their industry. The names of the 7 companies and their arbitrage contribution that day are shown in this figure.

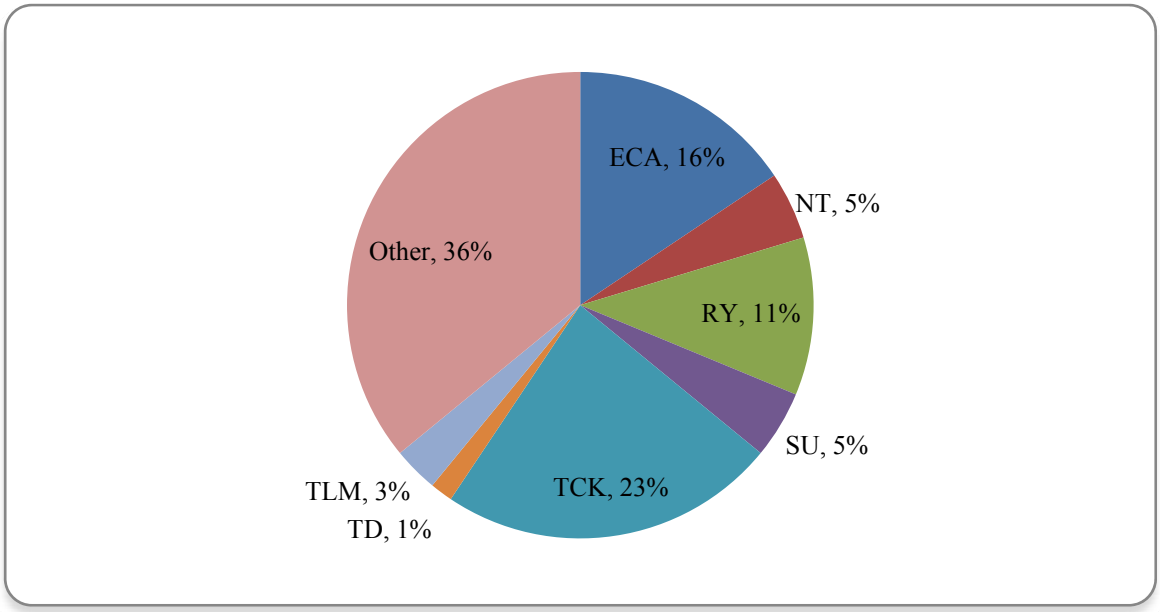
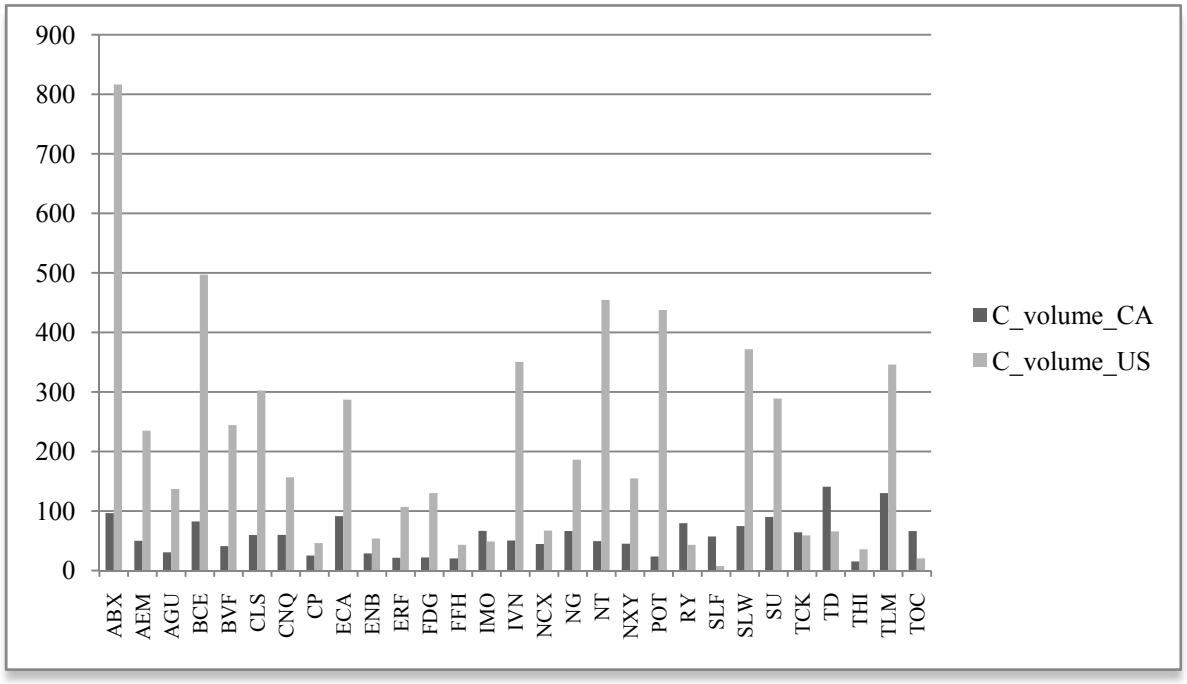


Figure 5: Trading volume of options in the US and Canadian markets

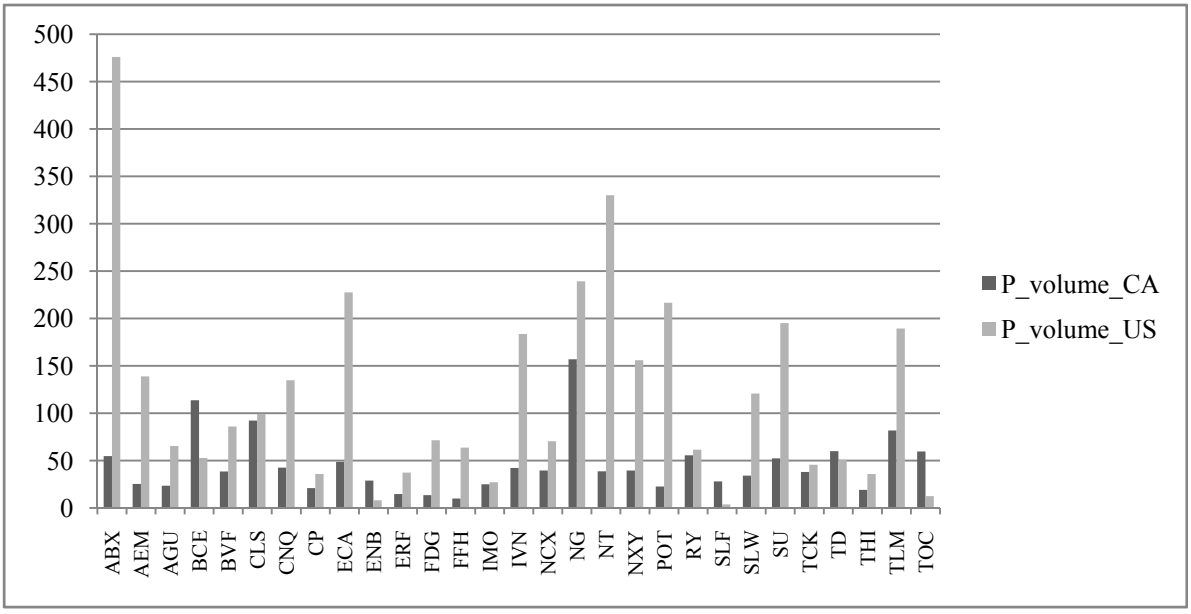
The first figure presents the trading volume of call options in the two countries. Average trading volume per option in the Canadian market is compared to its counterpart in the U.S. market, firm by firm.



C_volume_CA denotes the trading volume of call options issued by the cross-listed Canadian firms in Canadian market.

C_volume_US denotes the trading volume of call options issued by the cross-listed Canadian firms in the U.S. market.

The second figure presents the trading volume of put options in the two countries. Average trading volume per option in Canadian market is compared to its counterpart in the U.S. market, firm by firm.



P_volume_CA denotes the trading volume of put options issued by the cross-listed Canadian firms in Canadian market.

P_volume_US denotes the trading volume of put options issued by the cross-listed Canadian firms in the U.S. market.

Figure 6: Dramatic price drops in the Canadian market in 2007

This figure shows the closing price movements of the S&P/TSX composite index in 2007. The biggest 10 price drops as well as their potential reasons are labelled in this figure.

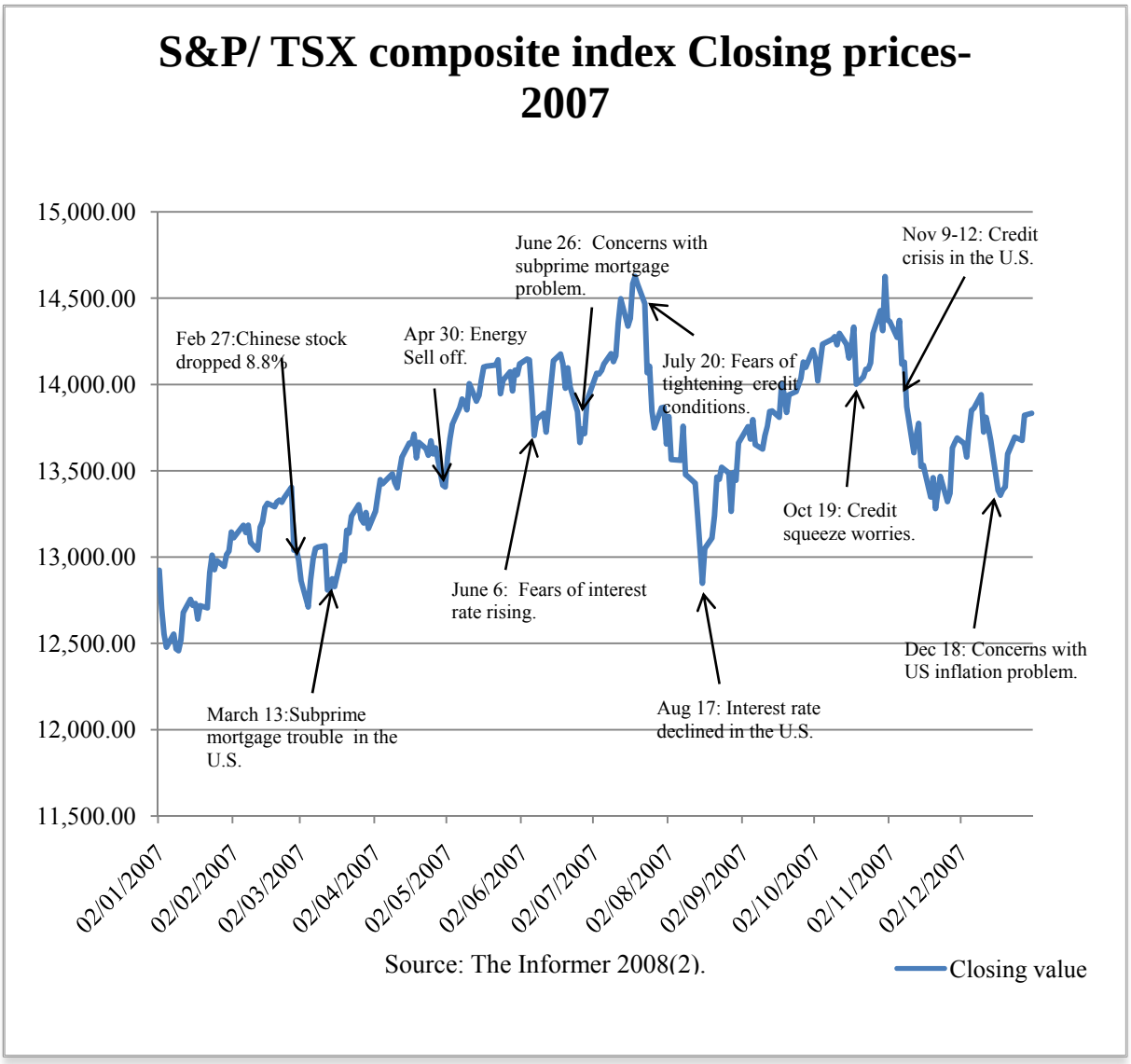


Figure 7: The time line of the 10 biggest stock price drops in the Canadian market in 2007

Figure 7 displays the time intervals between the 10 biggest price drops in the Canadian market 2007. It is obvious that the time interval between the first and second market slump is the shortest among the total 9 time intervals.

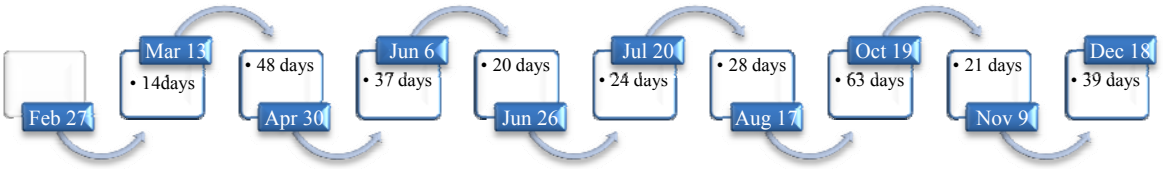


Figure 8: The option trading volume in the 10 biggest market price drops.

Figure 8 shows the option trading volume in market crash and its corresponding monthly average value. Average daily trading volume during the sharp price drops in the Canadian market is less than its corresponding monthly average, based on this Figure.