

**Evaluation of the pairs-trading strategy on the Toronto Stock  
Exchange: 2001-2010**

By

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## **Abstract**

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This paper focuses on evaluating the return characteristics of pairs-trading strategy on the Toronto Stock Exchange. Through analysis of trading results, we found a significant evidence to indicate that pairs trading strategy is consistent in achieving profitability on Toronto Stock Exchange. Moreover, profitability has a decreasing trend during the sample period of 2001 to 2010 and it is largely distorted by the global financial crisis from 2007-2009.

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# Chapter 1

## Introduction

### 1.1 Background of the study

Equity markets are where risks and uncertainties hide. In order to make a profit, investors seek opportunities mainly from two aspects: the market information they gather and the strategies they adopt. While some investors are focusing on particular companies or industries, others are refining strategies based on behaviors of the equity markets. Among all the well-known trading strategies, there is one called "pairs-trading".

“Pairs-trading” is one of the most popular yet oldest trading strategies adopted by Wall Street bankers and many institutional investors over the last few decades. The profitability of pairs-trading has been documented and confirmed in numerous research papers. It is considered a form of technical analysis which is easy to perform and does not require in-depth analysis of the market or individual firms. It has been more than a decade since the publication of the original research by Gatev et, al (2006) in which the robustness of the excess returns generated from this trading strategy was tested.

Although pairs-trading strategy is still being employed in the worldwide equity markets, it was always neglected as a field of research, especially in smaller markets such as the Canadian stock market. This paper seeks to evaluate the return

characteristics of pairs-trading strategy using daily data in the Canadian stock market in the recent 10-years period from January 2001 through December 2010.

### 1.2 Rationale of the study

The concept of pairs-trading is very simple: identify a potential pair of stocks whose stock prices exhibited a significant level of “closeness”. However, how to measure the level of “closeness” is subjective. Historically speaking, the concept of correlation, sum of the squared differences (SSD) of stock price, minimum distance between normalized historical data are all adopted in various research to identify a pair. Generally speaking, stocks in a potential pair will have historical prices that move closely to each other. Once a pair is identified, we take both long and short positions when their stock prices diverge abnormally in the hope that the prices will converge to the previous spread again and the strategy will lead to a profit. The “opening trigger” and “closing trigger” of the position depend on various criteria such as price spread, residual spread and distance between normalized price. We will be adopting the Spearman's rank correlation coefficient to identify potential pairs and we will be adopting residual spread to identify “opening trigger” and “closing trigger” in this paper.

### 1.3 Objective of the study

The objective of the study is to evaluate the risk and return characteristics of pairs-trading strategy in the Canadian stock market. It is believed that this will

provide insights to investors and help them understand the concept of market efficiency and the importance of quantitative analysis and marketing timing in equity trading.

#### 1.4 Limitation of the study

Pairs-trading strategy is purely a relative valuation model based on specific trading rules. Fundamental analysis and market condition are considered irrelevant in the process. However, the performance of pairs-trading strategy can be largely influenced under certain abnormal market condition. According to Kaan et al. (2010), during the recession in 2001-2002 when the Dot Com bubble burst, financial market conditions and movements were statistically insignificant thus to make quantitative analysis less useful and market players reluctant to adopt pairs-trading strategy.

This paper has limitations due to the fact that fundamental and firm specific factors are not captured in the trading analysis process and these factors have potential influence on our results.

#### 1.5 Chapter organization

After this brief introduction covering the basics of the study in this current Chapter, Chapter 2 will provide a literature review focusing on the previous work on the topic. Database sources and research methodology will be discussed in Chapter 3. Lastly, research analysis, result, conclusions will be covered in Chapter 4 and 5.





## **Chapter 2**

### **Literature Review**

The famous efficiency market hypothesis (EMH) has been tested in various research regarding Canadian markets. Basically, there are three forms that EMH can be presented: weak-form efficiency, semi-strong form efficiency and strong-form efficiency. In weak-form efficiency, it is asserted that all past information is fully reflected in share prices. Such information includes both historical trading data and market news and they should have no potential in determining future share price behavior. Under weak-form efficiency, trading strategies that focus on past price patterns and historical data should not be able to consistently beat the market. By investigating the weak-form efficiency of the Toronto Stock Exchange with respect to the life insurance sector, Bernier and Mouelhi (2009) argued that Canadian stock market is inefficient in equity pricing, especially during the period of market demutualization.

EMH has important implications for market participants to understand how efficient market neutral strategies will be when identifying mispriced equities. If the weak form of EMH hold, then any attempts to arbitrage based on historical information will not be beneficial.

However, against the efficiency market hypothesis, many researchers were able to show that historical data are useful in explaining and even predicting future stock

price movement. Many phenomenas were observed in both empirical and theoretical research, including the famous time anomalies such as Monday effect, January effect and turn of the month effect (Perlin, 2009). Also, historical data were tested to be able to explain the relationship between certain variables, for example, the size effect which states that stock return is negatively related with market capitalization of the common equity of a company, in short, the smaller the company, the smaller return (Elroy, 1988). In-depth reviews of the EMH can be readily available in the literature.

With the development of computer-based trading platforms, many researchers tried to adopt quantitative analysis to build specific trading rules and models. Under these models, the only data utilized were historical information. The core concept of these kinds of models is to create speculative positions that based on extensive analysis of historical stock price behavior (Perlin, 2009).

Among different quantitative approaches, technical analysis has drawn enormous attention in this field. The core of technical analysis is all about price movement. To interpret all the relevant information, a variety of technical indicators are developed and they fall into various categories: those to identify price trends such as moving averages and Bollinger band; those to show price turning point such as chart and relative strength index (Holter, 2008). Since the early 1990s, technical analysis was supported by both practitioners and academicians, many research have indicated that technical analysis was able to provide profitability and predictive power (Xavier, et al, 2010).

In the 1980's, a popular strategy called pairs-trading began to gain reputation.

Famous Wall Street “quant” Nunzio Tartaglia gathered a team of science elites from different fields including physics, mathematics and computer science. The team aimed to develop a complicated trading program by using statistical methods to discover arbitrage opportunities. The trading platform was purely based on pre-specified algorithms and human subjectivity was eliminated. The strategy was successful for a while, but not consistent and the team was disbanded after a period of disappointing performance (Gatev, et al. 2006).

Basically, pairs-trading is a type of statistical arbitrage mixed with technical analysis that tries to take advantage of the inefficiency of financial markets. The first step of pairs-trading is pair selection. Technical indicators are taken into account in the process and they are built into a complicated trading model. The second step involves actual trading and the execution can also be programmed so traders of all skill levels are able to perform the strategy and no specialized knowledge is required. With the development of modern financial markets, especially the growing number of financial derivatives and ETFs, pairs-trading strategy has developed and advanced. It is possible to match a single stock to an index, or simply create a pair by using appropriate stock options (Ehrman, 2004).

The reason why evaluating pairs-trading strategy in the Canadian stock market is intriguing is that since the original research by Gatev, et al (2006) very few studies have covered pairs-trading strategy. As far as we know, the only noticeable works are Kann et al (2010), Perlin (2009) and Broussard and Vaihekoski (2010) have contributed to this field. They evaluated pairs-trading on the Istanbul Stock Exchange,

Brazilian financial market and Finland stock market, respectively. Also, evaluating the performance of pairs-trading in a smaller and less liquid market such as Canada could bring more insights on the practicability of the strategy on a global basis.

## **Chapter 3**

### **Data sources and Methodology**

#### 3.1 The sources of data

Toronto Stock Exchange is the largest stock exchange in Canada and the third largest stock exchange in North America, it is a mature market that is continuously growing in shares traded and market capitalization. Numerous reputable data sources on the TSX index and individual stock data can be found, such as Bloomberg, Research Insight, TMX group and other professional data providers. The primary focus of this study is on the TSX composite index, which is the key indicator of Canadian economy. TSX composite index includes more than 70% of the total market capitalization of all Canadian-based firms listed on the Toronto Stock Exchange. The data on equity daily price movement, market return, individual stock beta, standard deviation and covariance are all extracted from the Bloomberg system.

The data collected from Bloomberg platform consist of a sample of 244 Canadian stocks as of December 31 2010 with the sample data incepts after January 2001 and before January 2011. The composition of TSX composite index is subject to certain criteria such as capitalization and liquidity. To maintain consistency, this paper will study the same stocks during the in-sample and out-sample period. We excluded illiquid stocks that have more than one day without trading. Stocks delisted during our pair formation period will also be excluded from our study.

### 3.2 Limitation of the data

Our data collection used in this study still has some limitations. First, since pairs trading is a typical technical arbitrage implemented using computerized technology with little to none external interventions, criteria for data collection in research including this study focus mainly on statistical significance. Signals for price co-movement and correlation from fundamental analysis are neglected. Also, false signals may rise because of company-specific news or temporary change in aggregate economic condition.

Second, because illiquid stocks and delisted stocks are excluded in order to mimic active market behavior, this study could be subject to the "Survivorship bias". "Survivorship bias" states that a disproportional weighting in better performing fund or equity can result in a overestimated report because the loser stocks ceased to exist at certain point during the studying period (Bu & Lacey, 2007).

### 3.3 Out of sample analysis

Since pairs trading strategy is a form of technical analysis, research findings are all based on historical information. Reliability and robustness of results and conclusions should be tested and it is always a good practice to do a out-of-sample testing. In the out-of-sample study, our trading strategy will first be tested on a given test period of 2001 to 2007. Then the same test will be run on a new test period of 2008-2010. Since the two periods have completely different size and sample of data,

difference in parameters between test-period and out-of -sample period will indicate whether pairs-trading strategy is over-optimized or under-optimized. Consistency of profitability can also be demonstrated by examining the test result.

### 3.4 Model employed and the construction of trading algorithm

In accordance with the pairs trading framework of Gatev et, al (2006), potential pairs are formed over a period of 12 months and then traded in the following 12 months. Each pair will be formed by ranking the Spearman's rank correlation coefficient during the pair formation period. Regression analysis will be utilized to help ensure the reliability of a pair. Pair formation will be performed every 12 months to mimic a active fund manager rotating investment strategy each year.

Once a pair is identified, both long and short positions will be placed during the trading period once their residual spread diverge by more than two standard deviations from the historical spread. Since we are analyzing the same equities during both in-sample and out-sample period, the potential influence from the event of stock delisting was eliminated. Positions will be closed on two conditions: on the last day of our trading period or when the residual spread converged to zero standard deviation from the historical spread. Performance will be measured in two ways, one is employed capital, which is total return divided by total pairs identified in the formation period and the other is committed capital, which is total average return divided by total pairs traded, because even a potential pairs is identified and expected to be traded in the trading period, opening trigger was not always triggered during the



trading period. By differencing committed capital and employed capital, we can effectively demonstrate how opportunity cost could affect research findings.

## Chapter 4

### Analysis of Results

#### 4.1 Model and analysis of results

##### 1.1 Parameters and trading algorithm

The parameters and trading algorithms applied in this study are shown below:

- i. Daily stock closing prices are used as the trade-in and trade-out price.
- ii. Parameter for opening trigger is set at two standard deviations from the historical spread.
- iii. Parameter for closing trigger is set at zero standard deviation from the historical spread.
- iv. Each pair is opened with both \$10,000 CAD long position and \$10,000 CAD short position for the purpose of dollar matching in order to maintain market neutral.
- v. Maximum number of days of trading is set at 12 months, if prices do not converge at the end of last trading day, both positions will be closed and gains or losses will be calculated as of the last trading day.
- vi. Transaction cost, margin requirement and borrowing cost are set at minimum to fully explore the return characteristic of the strategy.

#### 4.2 Example pair and trading process

According to the trading rules applied in this research, pairs of BMO CN Equity and TD CN Equity for the sample period of 2002/1/2 to 2003/1/2 is given as a example.

Pairs of BMO CN Equity and TD CN Equity are identified as a potential pair based on Spearman's rank correlation coefficient during the pair formation period of 2001/1/2 to 2002/1/2 with the correlation value of 0.661, R-Square of 0.437 and T-test of 14.177 (Table 4.1).

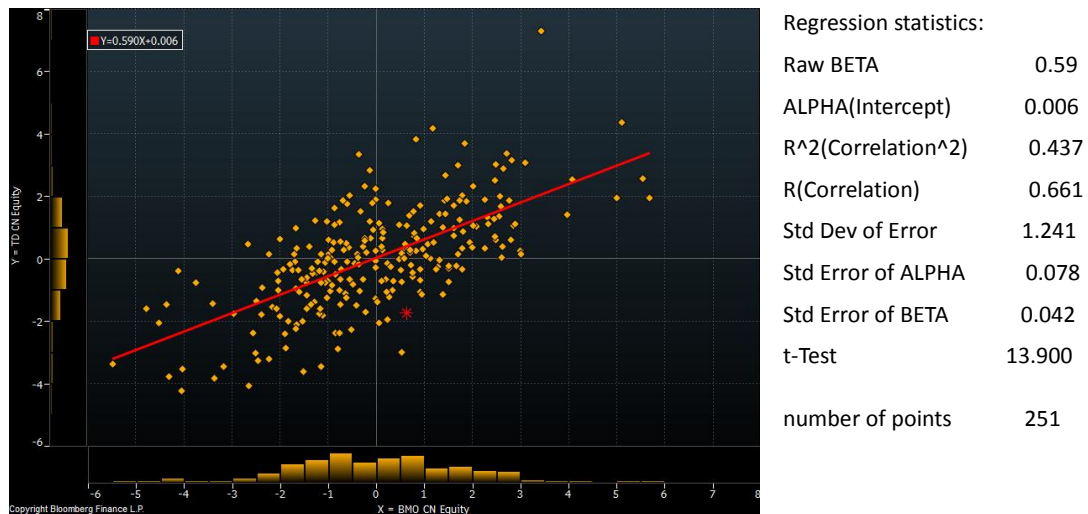
**Table 4.1**

Dependent	Independent	CORR	R2	COV	Std Err	Slope	Adj Beta	T-test
OCX CN Equity	CLS CN Equity	0.808	0.653	0.00129	0.016	0.386	0.591	22.092
PWF CN Equity	POW CN Equity	0.794	0.631	0.00023	0.010	0.789	0.860	21.025
TD CN Equity	CM CN Equity	0.721	0.520	0.00019	0.011	0.716	0.811	16.757
BMO CN Equity	CM CN Equity	0.683	0.467	0.00020	0.013	0.760	0.840	15.058
ESI CN Equity	PD CN Equity	0.681	0.464	0.00053	0.020	0.652	0.768	14.961
RIM CN Equity	CLS CN Equity	0.675	0.456	0.00273	0.052	0.819	0.879	14.730
BNS CN Equity	CM CN Equity	0.673	0.453	0.00019	0.013	0.732	0.822	14.653
TD CN Equity	BMO CN Equity	0.661	0.437	0.00019	0.012	0.590	0.727	14.177
TLM CN Equity	PD CN Equity	0.656	0.430	0.00040	0.016	0.488	0.658	13.973
RY CN Equity	TD CN Equity	0.651	0.424	0.00017	0.012	0.644	0.763	13.796
RY CN Equity	BNS CN Equity	0.638	0.408	0.00018	0.012	0.576	0.718	13.350
CNQ CN Equity	TLM CN Equity	0.635	0.403	0.00028	0.016	0.619	0.746	13.228
TD CN Equity	BNS CN Equity	0.633	0.400	0.00018	0.013	0.577	0.718	13.153
RIM CN Equity	OCX CN Equity	0.622	0.387	0.00120	0.055	1.579	1.386	12.787
ABX CN Equity	K CN Equity	0.618	0.381	0.00069	0.019	0.310	0.540	12.637
ABX CN Equity	AEM CN Equity	0.615	0.378	0.00043	0.019	0.489	0.660	12.550
K CN Equity	AEM CN Equity	0.611	0.373	0.00085	0.037	0.970	0.980	12.422
CNQ CN Equity	PD CN Equity	0.610	0.372	0.00036	0.016	0.442	0.628	12.379
RY CN Equity	BMO CN Equity	0.605	0.366	0.00018	0.013	0.534	0.689	12.222
RY CN Equity	CM CN Equity	0.603	0.364	0.00016	0.013	0.592	0.728	12.176

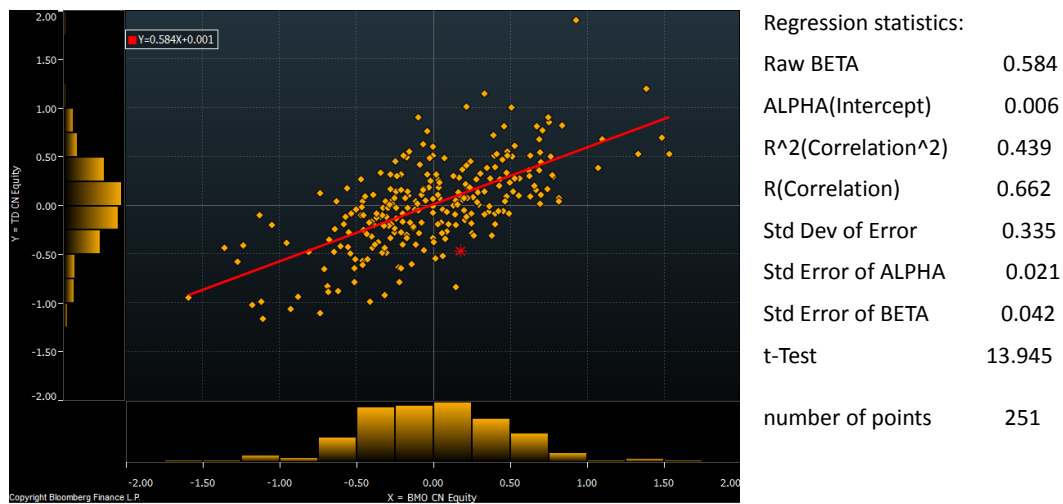
Note: This table summarizes the top twenty pairs based on Spearman's rank correlation coefficient with data of correlation, R-square, covariance, standard error, slope, adjusted-beta and t-test value. Results are for the sample period of 2001/1/2 to 2002/1/2.

With statistical values indicating a strong price co-movement, regression analysis was applied to ensure that this pair is a robust mean reversion candidate. During the pair formation period of 2001/1/2 to 2002/1/2, both regression fit for end-of-day prices and regression fit for natural log of prices indicated a statistical significant relationship between those two stocks in terms of price movement (Table 4.2).

**Table 4.2**



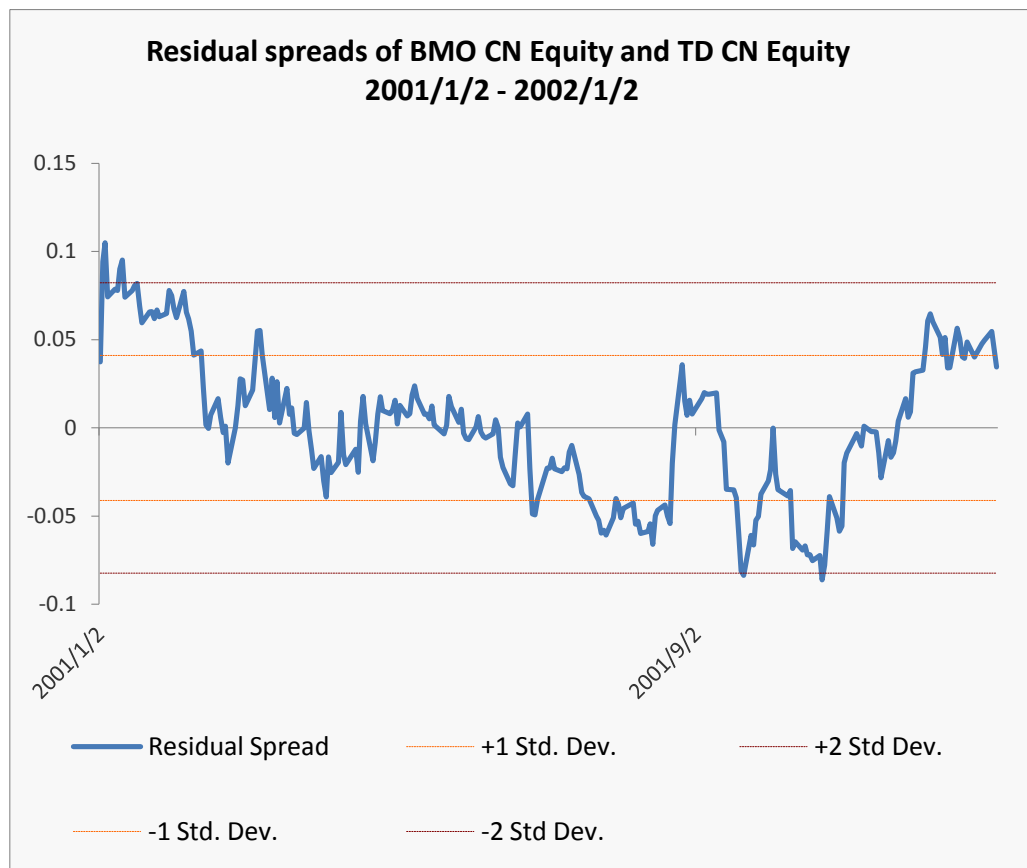
Note: Regression of end-of-day prices for TD CN Equity and BMO CN Equity for the sample period of 2001/1/2 to 2002/1/2.



Note: Regression of log value of end-of-day prices for TD CN Equity and BMO CN Equity for the sample period of 2001/1/2 to 2002/1/2.

The residual spreads chart during pair formation period (Table 4.3) is also showing a positive signal that this is a decent mean reversion pair when the frequency of spreads crossing zero is relatively high and the average time it took for each crossing is small.

**Table 4.3**



Note: Table 4.3 summaries the Residual spreads of BMO CN Equity and TD CN Equity during the pair formation period of 2001/1/2 to 2002/1/2

Trading strategy was then implemented during test period of the following 12 months from 2002/1/2 to 2003/1/2. With an opening trigger of two standard deviation multiplier for residual spread and \$10,000 CAD invested in both long and short positions, trading output was examined at the end of each trading period. Trade details

show that on 2002/1/9, soon after the strategy came into practice, a trading signal was detected and an entry of trade occurred according to the pre-specific trading rules. On 2002/5/17, an exit signal appeared and both short and long positions were closed on that day. Profit during the first trading cycle was \$1073.50CAD. On 2002/6/11, an entry signal was detected again. By the end of trading period, both positions were still open and they were subsequently closed according to trading rules. Total loss to close the positions was \$889.19CAD since prices of BMO CN Equity and TD CN Equity diverged quite significantly by the end of the trading period. Total profit for our entire trading period was \$184.31CAD, which yielded a total return of 0.005% for this pair.

#### 4.3 Analysis of the results

Table 4.4 summaries the return distribution for the top twenty pairs for trading period of January 2002 to December 2010.

**Table 4.4**

pair number	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011
1	0.373	0.593	0.131	0.302	0.321	0.123	0.252	0.258	0.157	0.222
2	0.309	0.498	0.112	0.198	0.097	0.121	0.165	0.138	0.080	0.159
3	0.252	0.161	0.083	0.156	0.092	0.086	0.120	0.138	0.069	0.052
4	0.160	0.085	0.066	0.152	0.078	0.060	0.113	0.130	0.049	0.049
5	0.079	0.073	0.064	0.147	0.073	0.036	0.078	0.129	0.044	0.028
6	0.073	0.049	0.042	0.141	0.051	0.024	0.071	0.102	0.042	0.025
7	0.062	0.043	0.026	0.138	0.042	0.010	0.050	0.102	0.036	0.018
8	0.059	0.018	0.013	0.121	0.029	0.009	0.049	0.090	0.026	0.006
9	0.041	0.009	0.002	0.119	0.019	0.005	0.049	0.082	0.020	-0.004
10	0.032	0.000	0.000	0.087	0.019	0.000	-0.015	0.076	0.017	-0.042
11	0.016	-0.002	-0.007	0.072	0.017	0.000	-0.076	0.075	0.014	-0.053
12	-0.006	-0.021	-0.008	0.044	-0.005	-0.003	-0.081	0.066	0.000	-0.071
13	-0.008	-0.058	-0.017	0.026	-0.013	-0.003	-0.112	0.045	0.000	-0.082
14	-0.044	-0.066	-0.022	0.019	-0.020	-0.008	-0.128	0.043	0.000	-0.084
15	-0.108	-0.088	-0.053	0.016	-0.025	-0.014	-0.128	0.027	-0.026	-0.098
16	-0.129	-0.096	-0.059	0.006	-0.055	-0.019	-0.149	0.000	-0.052	-0.117
17	-0.129	-0.109	-0.074	-0.008	-0.082	-0.034	-0.179	0.000	-0.053	-0.131
18	-0.158	-0.109	-0.085	-0.034	-0.089	-0.048	-0.249	-0.017	-0.079	-0.145
19	-0.167	-0.139	-0.093	-0.040	-0.146	-0.066	-0.257	-0.083	-0.088	-0.174
20	-0.188	-0.145	-0.100	-0.067	-0.153	-0.104	-0.290	-0.184	-0.167	-0.296
top 5 pairs	0.235	0.282	0.091	0.191	0.132	0.085	0.146	0.159	0.080	0.102
top 10 pairs	0.144	0.153	0.054	0.156	0.082	0.047	0.093	0.125	0.054	0.051
Committed capital	0.026	0.035	0.001	0.080	0.013	0.009	-0.036	0.061	0.005	-0.037
Employed capital	0.026	0.037	0.001	0.080	0.013	0.010	-0.036	0.061	0.005	-0.037
min	-0.188	-0.145	-0.100	-0.067	-0.153	-0.104	-0.290	-0.184	-0.167	-0.296
max	0.373	0.593	0.131	0.302	0.321	0.123	0.252	0.258	0.157	0.222
median	0.024	-0.001	-0.003	0.080	0.018	0.000	-0.046	0.075	0.016	-0.047
sd	0.157	0.193	0.067	0.093	0.102	0.056	0.151	0.092	0.070	0.116
skewness	0.687	2.051	0.267	0.449	1.102	0.450	0.003	-0.690	-0.403	0.147
kurtosis	0.042	4.103	-0.708	0.077	3.550	0.589	-0.859	2.208	1.376	0.911
negative return	45%	50%	50%	20%	45%	45%	55%	15%	30%	60%

Note: Table 4.4 summarizes the total return over different sample periods of the top 20 pairs formed from pair formation period. Statistic includes total return for the top 5, 10 and 20

pairs. "Committed capital" refers to the method of computing returns on committed capital; "Employed capital" refers to the method of calculating returns on employed capital. Minimum return, maximum return, median, standard deviation, skewness, kurtosis are demonstrated. observation of negative return refers to the percentage of how many pairs yielded negative return during trading period.

Overall, a declining trend was noticeable with two remarkable pickups in profitability in the recent bull market of January 2005 to December 2005 and January 2009 to December 2009 with total return of 7.98% and 6.09% respectively. A drastic decline in profitability was discovered in the recent bearish market of January 2008 to December 2008, with a negative return of 3.59%, which was incurred during the 2007-2009 global financial crisis. The overall declining trend in profitability was also documented in both the research of Gatev et, al (2006) and Do and Faff (2010). Do and Faff (2010) believed that increased competition between arbitrageurs has eventually led to increased arbitrage risk which includes both fundamental factors and trading noises.

In this practical study, many interesting finding are discovered as the trading process proceeded. First, numerous identical pairs repeated themselves during different trading cycle. Such pairs included TD CN Equity and BMO CN Equity, BNS CN Equity (Bank of Nova Scotia) and CM CN Equity (Canadian Imperial Bank of Commerce), and many other equities which are primarily involved in Canadian banking industry. This consistency of potential high correlation between banks is believed to be a result of banking concentration and collective phenomenas of increased operational risk in banking organizations (Reimer and Peter, 2008).

Second, consistent with the finding of Do and Raff (2010), returns on employed





#### 4.4 Implications for investors and researchers

The findings in this study have many implications for market practitioners who want to implement pairs-trading strategy. Generally, a great portion of profitability is driven by trading rules. The process of identifying pairs and executing trade are crucial. Reliable pairs should not only be located from perspectives that focus on price co-movement but also fundamental factors such as similar asset group and industry.

By locating pairs in same asset group or industry, non-convergence risk will be reduced. Also, fundamentally similar equity are more likely to express greater trend of convergence, such phenomenas can be seen in this study when numerous pairs in Canadian banking industry appeared in pair formation period. Future research on computerized trading program is suggested to refine trading algorithm as most losses in pairs-trading strategy of this paper occurred at the last day of trading period while positions are still open.

## **Chapter 5**

### **Conclusions and Recommendations**

#### 5.1 Conclusions

To examine the return characteristic of pairs-trading strategy at the Canadian equity market. The paper used the sample of 244 Canadian equity firms and the data of daily price movement, market return, individual stock beta, standard deviation and covariance during the years 2001 to 2010. The results argues that pairs trading strategy has a declining trend in profitability over sample period. Furthermore, profitability can be distorted by extreme market circumstance such as the 2007-2009 global financial crisis.

There is significant evidence to show that pairs in similar asset class or industry are more easily identified as potential pair. Profitability can be influenced by different aspects of trading rules.

#### 5.2 Recommendations and improvements

The data of the sample of 244 Canadian equity firms is based on the current year of 2010, thus, it excluded those equities delisted from the TSX composite index. If price information on all equities in the TSX composite index universe are available and included in this paper, results would be more accurate.

Moreover, what this paper discussed is only one of many practical methods of

pairs-trading strategy. Pair formation is subject to different criteria for price co-movement and trading algorithms are also customized by different market practitioners. Thus, it is unknown how pairs trading performance can be influenced by these subjectivities. More research and further studies on these terms can be done in the future.

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