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MASTER'S THESIS

PAIRS TRADING IN MOST TRADED TURKISH BANK STOCKS

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DECLARATION

I hereby declare that this master's thesis titled as "Pairs Trading In Most Traded Turkish Bank Stocks" has been written by myself in accordance with the academic rules and ethical conduct. I also declare that all materials benefited in this thesis consist of the mentioned resources in the reference list. I verify all these with my honour.

…/…/…….

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Signature

ABSTRACT

Master's Thesis

Pairs Trading in Most Traded Turkish Bank Stocks

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The objective of this thesis is to test if there is opportunity to make profit by using pairs trading strategy in six most traded Turkish bank stocks and their warrants in Borsa Istanbul. Co-integration test and error correction model are conducted for this test. Fifteen pairs which are consisted of six stocks are all co-integrated. After co-integration test, error correction model is estimated for all pairs, all pairs can be estimated with error correction model except one. For fourteen pairs which can be estimated with error correction model, pairs trading strategy is tested for stocks, for in the money and for out of the money warrants if there is opportunity to make profit. Pairs trading in stocks generally result in profit but these profits/losses are relatively low when they are compared with warrants. On the other hand, in the money warrants perform better than out of the money warrants for pairs trading. The reason is that the spread cost paid for out of the money warrants are higher than in the money warrants. Additionally, as pair holding period extends the loss in warrants increases or the profits in warrants decreases. The reason of this situation is that, as holding period extends, time value paid for warrants which means the cost increases. It is expected that, findings of the analysis will be beneficial for investors who want to use pairs trading with leveraged instruments, for financial institutions which would like to launch appropriate financial instruments for pairs trading and for regulatory and supervisory authorities.

Keywords: Pairs trading, statistical arbitrage, warrants, leveraged financial instruments, co-integration, error correction model, Borsa İstanbul, Turkish bank stocks.

ÖZET

Yüksek Lisans Tezi

En Çok İşlem Gören Banka Hisselerinde İkili İşlemler

Kerem ÖNDE

Dokuz Eylül Üniversitesi

Sosyal Bilimler Enstitüsü

İngilizce İşletme Anabilim Dalı

İngilizce Muhasebe ve Finansman Programı

Bu tezin amacı, Borsa İstanbul'da en çok işlem gören altı bankanın hisse senedi ve varantlarında ikili işlem stratejisi ile işlem yaparak kar edilip edilemeyeceğinin test edilmesidir. Bu testin yapılmasında eş bütünleşme testi ve hata düzeltme modeli birlikte kullanılmıştır. Altı hisseden oluşan on beş çiftin tümü eş bütünleşiktir. Eş bütünleşme testinin sonrasında tüm çiftler için hata düzeltme modeli uygulanmış, bir çift dışında tüm çiftler için hata düzeltme modeli uygulanabilir olarak bulunmuştur. Hata düzeltme modelinin uygulanabilir olduğu on dört çift için hisse senedi, asli değersiz ve asli değerli opsiyonlarda ikili işlemler stratejisi uygulanarak kar edilip edilemeyeceği test edilmiştir. Hisse senedi ikili işlemlerinde genellikle kar elde edilirken varantlara göre bu karlar/zararlar görece düşük kalmıştır. Diğer taraftan ikili işlemler sonucu asli değerli varantlar, asli değersiz varantlara göre daha iyi performans göstermiştir. Bunun en önemli nedeni, asli değersiz varantlar için ödenen spread (alım-satım arasındaki fark) maliyetinin daha yüksek olması olarak değerlendirilmiştir. Buna ek olarak ikili işlem pozisyonunu elde tutma süresi uzadıkça varantlarda edilen zararın arttığı ya da karın azaldığı görülmüştür. Buna sebep olanın ise; elde tutma süresinin uzamasıyla ödenen zaman değerinin, yani maliyetin artması olduğu gözlemlenmiştir. Analizden elde edilen bulguların kaldıraçlı finansal enstrümanları kullanarak ikili işlem yapmak isteyen yatırımcılara, ikili işlemlere uygun finansal enstrüman sunmak isteyen finansal kurumlar ile düzenleyici ve denetleyici kuruluşlara yararlı olması beklenmektedir.

Anahtar kelimeler: İkili işlemler, istatistiki arbitraj, varantlar, kaldıraçlı finansal enstrümanlar, eş bütünleşme, hata düzeltme modeli, Borsa İstanbul, Türk banka hisseleri.

PAIRS TRADING IN MOST TRADED TURKISH BANK STOCKS

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INTRODUCTION

Quantitative trading, also known as algorithmic trading, is the trading of securities based strictly on the buy/sell decisions of computer algorithms. The computer algorithms are designed and perhaps programmed by the traders themselves, based on the historical performance of the encoded strategy tested against historical financial data (Chan, 2009:1). Institutions and traders use these algorithms to take the advantage of high speed trading and they aim to move faster than others to make profit.

Statistical pairs trading is a relative value arbitrage on two securities and based on the premise that there is a long-run equilibrium between the prices of the stocks composing the pair (Vidyamurthy, 2004:84). Statistical pairs trading is one type of quantitative trading. Institutions and traders create trading signals by using pairs trading strategy. They aim to determine the opening and closing time of pair positions by using mathematical formulas.

Pairs trading can be called “statistical arbitrage” and traders use pairs trading for utilizing market abnormalities. The main objective of traders who use pairs trading as a trading strategy is exactly to make profit. They trade relatively overvalued or undervalued financial instrument, without taking downside or upside risk on market.

In the mid-1980s, the Wall Street quant Nunzio Tartaglia assembled a team of physicists, mathematicians, and computer scientists to uncover arbitrage opportunities in the equities markets. Tartaglia’s group of former academics used sophisticated statistical methods to develop high-tech trading programs, executable through automated trading systems, which took the intuition and trader’s ‘‘skill’’ out of arbitrage and replaced it with disciplined, consistent filter rules. Among other things, Tartaglia’s programs identified pairs of securities whose prices tended to move together. They traded these pairs with great success in 1987—a year when the group reportedly made a $50 million profit for the firm. Although the Morgan Stanley group disbanded in 1989 after a couple of bad years of performance, pairs trading has since become an increasingly popular ‘‘market neutral’’ investment strategy used by individual and institutional traders as well as hedge funds. The increased popularity of quantitative-based statistical arbitrage strategies has also apparently affected profits. In a New York Times interview, David Shaw, head of one

of the most successful modern quant shops and himself an early Tartaglia's protégé suggests that recent pickings for quant-shops have become slim—he attributes the success of his firm, D. E. Shaw, to early entry into the business. Tartaglia's own explanation for pairs trading is psychological. He claims, ''... Human beings don't like to trade against human nature, which wants to buy stocks after they go up not down'' [Hansell (1989)]. Could pairs traders be the disciplined investors taking advantage of the undisciplined over-reaction displayed by individual investors? This is at least one possible—albeit psychological—explanation for our results, which is consistent with Jegadeesh and Titman's (1995) finding that contrarian profits are in part due to over-reaction to company-specific information shocks rather than price reactions to common factors (Gatev et al., 2006: 799).

In the literature there are many models used to analyze pairs trading. Co-integration, error correction, Omstein-Uhlenbeck, Gaussian Markov chain model are some of them. In this study, pairs will be tested if they are co-integrated and then error correction model will be estimated for pairs which are co-integrated. Pairs which can be estimated with error correction model will be tested if they result in profit or loss by trading stocks and warrants for next period.

There are some reasons for using error correction model in this research. Warrants differ from option contracts as they can be sold at the beginning by their issuer only. So retail traders are not able to sell warrants at the beginning. Retail traders have to pay time value for warrants if they want to use them in pairs trading. So, the speed of correction of pair becomes very important. That's why error correction model is estimated and the estimations of error correction model are used as the number of trading day to hold pair position.

The findings of this study will be useful for investors who use pairs trading as a trading strategy by introducing a new perspective. It will help them by giving some hints in using warrants. So, they could find which factors should be considered while using warrants for pairs trading. Additionally, estimations of error correction model are used as number of trading days. Each pair positions are held for these numbers of days. It will also give an idea to traders to use error correction model's output while taking short term leveraged pair positions.

In addition to investors, regulatory and supervisory authorities, financial institutions will benefit from this study. They can understand the sense of pairs trading. Financial institutions can launch suitable instruments for traders who want to use pairs trading. Outperformance warrants and options can be good example as

instruments which are best fit for pairs trading. Regulatory and supervisory authorities can also make appropriate regulations and establish well organized surveillance systems for pairs trading.

So, in this study most traded banks (Garanti, Halkbank, Akbank, Yapı Kredi, Vakıfbank and İş bank) whose warrants are traded in Borsa İstanbul are chosen as stocks and they are paired with each other. As all paired stocks are chosen from same industry and country, many types of risks are eliminated. By using pairs which are from same industry, only firm specific risk could be exposed to the pair positions.

In this research it is found that out of the money (OTM) and in the money (ITM) warrants both result in higher profit or loss compared to stocks by using leverage. Another result is when pairs holding-day number increases, time value paid for warrants increases. There is no chance to make profit by using pair trading strategy.

Another result is that ITM warrants perform better than OTM warrants. The reason of this finding is ITM warrants' average spread cost is less than OTM warrants' average spread cost.

CHAPTER ONE
PAIRS TRADING AND RELATED STUDIES

Quantitative trading, also known as algorithmic trading, is the trading of securities based strictly on the buy/sell decisions of computer algorithms. Quantitative trading strategies are a combination of technical and statistical analysis which generate buy and sell signals. These signals may be triggered either through price patterns or values of complex indicators calculated from market prices. A trading strategy (also called a trading system or trading methodology) is a set of rules that signal the trader when to buy, when to sell, and when to sell short a market. The buy and sell decisions are typically generated by price patterns and indicators. These strategies can be very simple such as buy on Wednesday and sell on Friday. The signals can also be very complex and include statistical regression and relationships between many related markets (Kestner, 2003:15).

There are three building blocks for creating any algorithmic trading system: entries, exits, and filters. Entries are the signals that generate the opening buy and sell orders for new positions. Exits indicate that the expected value of a trade has diminished to the point that the trade should be closed. Filters persuade the trader to only take the entries with highest expected profits over the life of a system (Kestner, 2003:55). In this research, our entry is when error terms exceed more than 2 standard deviations in pair regression, our exit is calculated by error correction model and our filter can be not to hold highly leveraged warrants for a long period.

There are many types of algorithmic trading strategies. Volume Weighted Average Price, Time Weighted Average Price, Percentage of Volume, Search for Liquidity (Black Lance), Stay Parallel with the Market (Pegging) and Pairs Trading are the most popular strategies.

Pairs trading which is used in this research is market-neutral by its very structure as its operation does not depend on the direction of the market but on the correlative and anti correlative behavior of the stock being traded.

When the correlated stocks started moving in opposite directions the strategy was simply to short the out-performing one and long the under-performing one. The conjecture continues with the thought that the two stocks will exhibit a reversion to the mean type behavior and converge back to moving parallel. When this happens we obviously close out the trade with two profits.

To trade a pair strategy we have to find two stocks which are highly correlated over our lookback period. The algorithm will watch out for their movement out of the security envelope and once the deviation crosses the trader's preset limit will go into action. It will monitor progress (sometimes for quite an extended time period, such as days or even weeks) and when the prices revert to their normal correlation it will close out the trade (Leshik and Cralle, 2011:23).

1.1. LITERATURE REVIEW

Literature on pairs trading is rare and it is hard to find many articles on this topic. Furthermore it is very hard to categorize articles on pairs trading, because articles on this topic are very heterogeneous. So, this part will be given on two subtitles: articles on algorithmic trading and articles on pairs trading.

1.1.1. Articles on Algorithmic Trading

Boehmer et al. (2015) studied the effect of algorithmic trading intensity on equity market liquidity, short-term volatility, and informational efficiency between 2001 and 2011 in 42 equity markets around the world. On average, algorithmic trading improves liquidity and informational efficiency but increases volatility. They attributed the algorithmic trading-related increase in volatility neither to more "good" volatility that would arise from faster price discovery nor to algorithmic traders' inclination to enter the market when volatility is high. On the contrary, these volatility-seeking traders are associated with declines in market quality. Their results are consistent across markets and thus across a wide range of algorithmic trading practices. But results vary in the cross-section of stocks. In contrast to the average effect, greater algorithmic trading intensity reduces liquidity.

Hendershott et al. (2011) studied algorithmic trading and its role in the price formation process. They found that algorithmic trading consumed liquidity when it was cheap and provide liquidity when it was expensive. Algorithmic trading contributed more to the discovery of the efficient price than human trading. Their results demonstrated that algorithmic trading closely monitored the market in terms of liquidity and information and reacted quickly to changes in market conditions. They found no evidence of algorithmic trading behavior that would contribute to volatility beyond making prices more efficient.

Chaboud et al. (2014) studied the impact of algorithmic trading in the foreign exchange market using a long time series of high-frequency data that identify computer-generated trading activity. They found that algorithmic trading causes an improvement in two measures of price efficiency: the frequency of triangular arbitrage opportunities and the autocorrelation of high frequency returns. They showed that the reduction in arbitrage opportunities is associated primarily with computers taking liquidity.

Purnendu Nath (2003) examined the implementation of a simple pairs trading strategy with automatic extreme risk control using the entire universe of securities in the highly liquid secondary market for U.S. government debt. Nath found that pairs trading strategy suggested perform well relative to various benchmarks and using different measures of performance. Even as an unsophisticated strategy it allows a trader to benefit from any predictability in spreads between bonds and short-lived mis-pricing of bonds.

Brownlees et al. (2011) proposed a dynamic model for intra-daily volumes that captures salient features of the series such as time series dependence, intra-daily periodicity and volume asymmetry. They also introduced loss functions for the evaluation of proportion forecasts which retained both an operational and information theoretic interpretation. An empirical application on a set of widely traded index Exchange Traded Funds showed that the proposed methodology is able to significantly outperform common forecasting methods and delivered more precise predictions for Volume Weighted Average Price trading.

1.1.2. Articles on Pairs Trading

Lin et al. (2006) used cointegration principles to develop a procedure that embeds a minimum profit condition within a pairs trading strategy. They derived the necessary conditions for such a procedure and then used them to define and imlplement a five-step procedure for identifying eligible trades. The statistical validity of the procedure is verified through simulation data. Practicality is tested through actual data. The results showed that, at reasonable minimum profit levels, the protocol does not greatly reduce trade numbers or absolute profits relative to an unprotected trading strategy.

Mudchanatongsuk et al.(2008) proposed a stochastic control approach to the problem of pairs trading. They modeled the log relationship between a pair of stock

prices as an Ornstein-Uhlenbeck process and used this process to formulate a portfolio optimization based stochastic control problem. They obtained the optimal solution to this control the problem in closed form via the corresponding Hamilton-Jacobi-Bellman equation. They also provided closed form maximum-likelihood estimation values for the parameters in the model.

Hendershott and Riordan (2013) examined the role of algorithmic traders in liquidity supply and demand in the 30 Deutscher Aktien Index stocks on the Deutsche Boerse in January 2008. Algorithmic traders represent 52% of market order volume and 64% of nonmarketable limit order volume. Algorithmic traders more actively monitor market liquidity than human traders. Algorithmic traders consume liquidity when the bid-ask quotes are narrow and supply liquidity when the bid-ask quotes are wide.

Panyagometh (2013) indicated that the investment portfolio applying the Pairs Trading strategy could significantly generate higher returns than sole investment portfolio in low PER and PBV stocks for either short or long investment period. However, if the risk was also taken into consideration, the Pairs Trading investment portfolio could still generate higher returns than the compared investment portfolio under risk comparison perspective.

Andrade et al. (2005) tried to understand the profitability pairs trading. They showed that pairs strategies work in Taiwan. They found that initial price divergence is highly correlated with uninformed shocks to the underlying stocks. They concluded that non-informational shocks have an economically and statistically significant impact on asset prices. The profits to the pair's trading strategy represent another way to quantify the economic impact of the limited risk-bearing capacity.

Linderberg (2014) modeled the spread between two assets as an Omstein-Uhlenbeck process and assumed a constant opportunity cost and studied the optimal liquidation strategy for an investor who wanted to optimize profit in excess of the opportunity cost. Including this opportunity cost is important from an applied perspective, as the performance of any investment is always evaluated relative to the performance of the opportunity set.

Dunis et al. (2010) applied a pair trading strategy to the constituent shares of the Eurostoxx 50 index. They implemented a basic long-short trading strategy which was used to trade shares sampled at 6 different frequencies, namely data sampled at 5-minute, 10-minute, 20-minute, 30-minute, 60-minute and daily intervals. They introduced an approach to select the best pairs for trading based on the in-sample

information ratio of the series, the in-sample t-stat of the ADF test of the series sampled at a daily interval and a combination of the two, as these were shown to be good indicators of the out-of-sample profitability of the pair. They then built a diversified pair trading portfolio based on the 5 trading pairs with the best in-sample indicator value. Their diversified approach was able to produce information ratios of over 3 for a high frequency sampling interval (an average across all the high-frequency intervals considered), and 1.3 for a daily sampling frequency using the in-sample information ratio as an indicator. This was a very attractive result when compared to the performance of the Eurostoxx 50 index and the index of Market Neutral Hedge Funds with information ratios lower than 1 during the review period. It also showed how useful the combination of the high-frequency data and the concept of cointegration could be for quantitative fund management.

Caldeira and Moura (2013) applied cointegration tests to identify stocks to be used in pairs trading strategies. In addition to estimating long-term equilibrium and to modeling the resulting residuals, they selected stock pairs to compose a pairs trading portfolio based on an indicator of profitability evaluated in-sample. The profitability of the strategy is assessed with data from the Sao Paulo stock exchange from January 2005 to October 2012. Their empirical analysis showed that the proposed strategy exhibit excess returns of 16.38% per year, Sharpe Ratio of 1.34.

Bertram (2010) derived analytic formulae for statistical arbitrage trading where the security price follows an Ornstein Uhlenbeck process. By framing the problem in terms of the first passage time of the process, he derived expressions for the mean and variance of the trade length and the return. He examined the problem of choosing an optimal strategy under two different objective functions: the expected return, and the Sharpe ratio. He said that he obtained an exact analytic solution for the case of maximizing the expected return.

ChoiChiu and Wong (2011) claimed that they completely solved the continuous-time mean–variance problem of cointegrated assets in a complete market. They recognized that an exponential affine form was useful in the solution process given the particular structure of cointegration dynamics. The derivation was then converted into solving a system of ODEs that admits well known standard solution methods. The results are applied to analyze the pairs trading of cointegrated assets. Their numerical examples show that the solution can be efficiently implemented given the parameter values, and illustrates interesting properties of a mean–variance pairs trading strategy for cointegrated assets. Their

empirical example illustrates the practical use of the method and shows a case in which their strategy outperforms the use of a simple log-normal model for a cointegrated pair of assets.

Broussard and Vaihekoski (2012) investigated the practical issues of implementing the self-financing pairs portfolio trading strategy presented by Gatev et al. (2006). They also provided new evidence on the profitability of pairs trading under different weighting structures and trade initiation conditions. Using data from the Finnish stock market over the period 1987–2008, they found pairs trading to be profitable even after allowing for a one day delay in the trade initiation after the signal. Lowering the threshold for opening a pair is found to increase returns even after accounting for trading costs, indicating that there might be a more optimal trade initiation threshold available than that presented in earlier literature. The profits are not related to market risk. Pairs trading strategy is found to produce positive alpha during the sample period.

Jacobs and Weber (2015) performed large-scale empirical analysis of pairs trading, a popular relative-value arbitrage approach. They started with across country study of 34 international stock markets and uncover that abnormal returns are a persistent phenomenon. They then constructed a comprehensive U.S. data set to explore the sources behind the puzzling profitability in more depth. Their findings indicated that the type of news leading to pair divergence, the dynamics of investor attention as well as the dynamics of limits to arbitrage are important drivers of the strategy's time-varying performance.

Elliott et al. (2005) provided an analytical framework for pair’s investment strategy. They propose a mean reverting Gaussian Markov chain model for the spread which is observed in Gaussian noise. Predictions from the calibrated model were then compared with subsequent observations of the spread to determine appropriate investment decisions. The methodology had potential applications to generating wealth from any quantities in financial markets which were observed to be out of equilibrium.

Gatev et al. (2006) tested a Wall Street investment strategy, ‘‘pairs trading’’, with daily data over 1962–2002. Stocks were matched into pairs with minimum distance between normalized historical prices. A simple trading rule yielded average annualized excess returns of up to 11% for self-financing portfolios of pairs. The profits typically exceeded conservative transaction-cost estimates. Bootstrap results suggested that the ‘‘pairs’’ effect differs from previously documented reversal profits.

Robustness of the excess returns indicated that pairs trading profits from temporary mispricing of close substitutes. They linked the profitability to the presence of a common factor in the returns, different from conventional risk measures.

Jacobsen (2008) applied cointegration analysis with an error-correction model to show how the long-run relationship is approached when the security prices are out of line with their cointegrated relationship. They sought to fill that gap of previous studies about using error correction model, by presenting how to implement a statistical arbitrage strategy based on cointegration and error-correction modeling.

Perlin (2009) tried to answer to question if pairs-trading strategy presented positive performance for the Brazilian market. The main objective of the research was to verify the performance and risk of pairs-trading in the Brazilian financial market for different frequencies of the database: daily, weekly and monthly prices for the same time period. The main conclusion of his simulation was that pairs-trading strategy had been a profitable and market-neutral strategy at the Brazilian market. Such profitability was consistent over a region of the strategy's parameters. The best results were found for the highest frequency (daily), which was an intuitive result.

Kurun et al. (2010) performed pairs trading strategy based on a comparative mean reversion of asset prices with daily data over the period 2002 through 2008 in Istanbul Stock Exchange. They did not categorize stock pairs by sectors and therefore they had possibility to observe mean reversion characteristics of different stocks that were selected from ISE- 30 index. The initial formation period was 125 days (approx. 6 months) while they measured the performance results daily. Then both formation process and trading strategies had been structured as dynamic (rolling windows) market trading model through 2008. The results indicated that pairs produced average returns of 3.36 % daily comparing with individual stocks within the index and the index itself. However ISE30 daily average return performance was 0.038 % between 2002-2008. Their trading constraints and trading commissions take away the excess return on pairs mostly. Furthermore, the performance analysis revealed that the pairs trading strategy yielded excess returns with less volatility than the market portfolio.

Avellaneda and Lee (2010) studied model-driven statistical arbitrage in US equities. They generated trading signals in two ways: using Principal Component Analysis (PCA) and regressing stock returns on sector Exchange Traded Funds

(ETFs). In both cases, the idiosyncratic returns were modelled as mean-reverting processes, which leaded naturally to ‘contrarian’ strategies. They constructed back test and compared market-neutral PCA- and ETF-based strategies applied to the broad universe of US equities. After accounting for transaction costs, PCA-based strategies had an average annual Sharpe ratio of 1.44 over the period 1997 to 2007, with stronger performances prior to 2003. During 2003–2007, the average Sharpe ratio of PCA-based strategies was only 0.9. ETF-based strategies had a Sharpe ratio of 1.1 from 1997 to 2007, experiencing a similar degradation since 2002.

Baronyan et al. (2010) investigated several market-neutral trading strategies and found empirical evidence that market-neutral equity trading outperformed in 2008, the first full year of the global financial meltdown. In their experiments they used 14 distinct market-neutral trading strategies, using the combination of seven trading methods and two selection methods of pairs trading. They showed that market-neutral trading performs best during the most severe market conditions.

Gutierrez and Tse (2011) found that the profitability of the strategy hinges on a co-integrated relation, which Engle and Granger [1987] showed also implied an error-correcting relation. Simply stated, the most important feature of arbitrage, particularly in terms of how it relates to pairs trading, is the convergence of a temporary pricing flaw back to its expected values. The results of their study showed that although a trader might not be able to foresee the movement of the co-integrating leader, that move generates a predictable response from the co-integrating follower, which the pairs trading strategy is able to capitalize on and profit from.

Do and Faff (2006) analyzed existing methods in detail and proposes a general approach to modeling relative mispricing for pairs trading purposes, with reference to the mainstream asset pricing theory. Several estimation techniques are discussed and tested for state space formulation, with expectation maximization producing stable results. Their empirical evidence showed clear mean reversion behavior in selected pairs.

Li et al. (2014) used the daily data for 38 companies during the period of 2009–2013, and they examined the long-run equilibrium between the stock prices of firms dual listed on A-share market in China and H-share market in Hong Kong, and exploited the arbitrage opportunity for investors. They proposed a simple self-financing trading strategy which was derived from the short-run disequilibrium price path. Their results demonstrated that cointegration and error-correction mechanism

existing between the A-share and the H-share. In addition, their proposed trading strategy actually beat the markets and provided superior performance in terms of Sharp Ratio and value at risk statistics. Further analysis on international asset pricing model demonstrated that their trading strategy yields an average annualized excess return of about 17.6% when adjusted for the systematic risk.

Huck and Afawubo (2015) used the components of the S&P 500 index, explored the performance of a pairs trading system based on various pairs selection methods. They dealt with well-known statistical and econometric techniques such as stationarity and cointegration which make the trading system much more demanding from a computational point of view. Trades were initiated when stocks deviate from their equilibrium. Their results confirmed, after controlling for risk and transaction costs, that the distance method generated insignificant excess returns. While a pairs selection following the stationarity criterion leaded to a weak performance, this article revealed that cointegration provides a high, stable and robust return.

Haque and Haque (2014) used daily stock prices of 20 stocks listed in Dhaka Stock Exchange. Their research first identified a pair of stocks whose prices have a long-run equilibrium using Johansen's test for cointegration. The cointegrated stock pair is then modeled using a Vector Error Correction Model. The residual obtained from the estimated model served as the guide to implementing Pairs Trading Strategy. The research finally identified three pairs of stocks which have general long-run equilibriums. Based on the residual series of these pairs, they implemented pairs trading strategy for a period of one to two months using real time data but doing hypothetical trading. It generated significant returns for all trades carried out using both in-sample and out-of-sample data.

Miao (2014) proposed a high frequency and dynamic pairs trading system, based on a market-neutral statistical arbitrage strategy using a two-stage correlation and cointegration approach. The proposed pairs trading system was applied to equity trading in U.S. equity markets in any type of market cycle condition to capture statistical mispricing between the prices of each stock pair based on its residuals and to model the stock pairs naturally as a mean-reversion process. The proposed pairs trading system was tested for out-of-sample testing periods with high frequency stock data from 2012 and 2013. Our trading strategy yields cumulative returns up to 56.58% for portfolios of stock pairs, well exceeding the S&P 500 index performance by 34.35% over a 12-month trading period. The proposed trading strategy achieved a monthly 2.67 Sharpe ratio and an annual 9.25 Sharpe ratio.

Furthermore, the proposed pairs trading system performed well during the two months in which the S&P 500 index had negative returns. Thus, the trading system might be especially more profitable at times when the U.S. stock market performed poorly. Therefore, the performance returns of the proposed pairs trading system were relatively market-neutral and were positive regardless of the performance of the S&P 500 index.

The findings of this study will be important because a new trading strategy especially for warrants as highly leveraged financial instruments which are traded in Borsa Istanbul is introduced. Apart from other studies, in this study a leveraged financial instrument is used. Warrants' characteristics and how to use warrants are given in a detailed manner.

Additionally, estimations of error correction model are used to find number of trading days for each pair apart from other studies. In other studies, generally pair positions are held and waited for two stocks' ratio return to long term average. But for warrants that much time will result very high loss because of time value. The longer time positions are held, the more costly warrant trading will be. So in this thesis, a real profit/loss of a trader who analyzed past data and traded for next period can be seen.

1.2. METHODOLOGY

In this thesis, pair positions are opened when two paired stocks' ratio deviated from long run equation on daily basis. Pair positions are opened as long position in relatively undervalued stocks and short position in relatively overvalued stocks for the same amount of Turkish Liras. While holding pair position, it is expected that deviated stocks' ratio should make move to on opposite direction within a few days which can be called error correction. This tendency to revert to long run mean ensures cointegration which can be summarized as two financial assets move together in the long run.

The paired stocks should be cointegrated which means they are in long run equilibrium. But for inefficient market conditions, a paired stock can be overvalued or undervalued compared to another. In that case, error term values increase considerably in regression of paired stocks. Error correction model has become crucial when the error term values increase. In regression, error terms are added

and it is expected that their sign is negative which means tendency return to the mean.

Therefore in this study, cointegration is used to pair each stock. The cointegrated pairs are tried to be modelled with error correction. Error correction model's outputs are used for holding period of pair position.

Let w_t be a k ×1 vector of variables, then the components of wt are integrated of order (d, b) if:

(1) All components of wt are I(d)

(2) There is at least one vector of coefficients α such that

$$a^1 w_t \sim \text{I(d} - \text{b)}$$

Cointegration is a long-term relationship between two time series that are both I(1), but a linear combination of the two series is I(0). If you have two time series, p_t^1, p_t^2, a linear relationship that is stationary can be represented as follows:

$$p_t^1 - \chi\, p_t^2 = \varepsilon_t$$

To be stationary, and for χ to be the cointegrating factor, ε_t must have a constant mean, variance and autocovariance (Jacobsen, 2008).

In practice, many financial variables contain one unit root, and are thus I(1), where d = b =1. In this context, a set of variables is defined as cointegrated if a linear combination of them is stationary. Many time series are non-stationary but 'move together' over time that is, there exist some influences on the series (for example, market forces), which imply that the two series are bound by some relationship in the long run. A cointegrating relationship may also be seen as a long-term or equilibrium phenomenon, since it is possible that cointegrating variables may deviate from their relationship in the short run, but their association would return in the long run (Brooks, 2008:336).

The explanation for cointegration dynamics is captured by the notion of error correction. The idea behind error correction is that cointegrated systems have a long-run equilibrium; that is, the long-run mean of the linear combination of the two time series. If there is a deviation from the long-run mean, then one or both time series adjust themselves to restore the long-run equilibrium. The formal theorem stating that error correction and cointegration are essentially equivalent

representations is called the Granger representation theorem (Vidyamurthy, 2004:76).

Bank stocks which are used for analysis in this study are expected to move together because they have similar risks, such as country and sector risks. Only firm specific risk will make difference on relative prices. In the study, error correction model is used to analyze the tendency to turn to mean for each pair. In Chapter 2, pairs which can be estimated with error correction tested if they make profit or loss. Pair positions are opened when each stock is relatively undervalued or overvalued daily and for the number of trading day holding pair position, error correction model's estimations are used.

When the concept of non-stationarity was first considered in the 1970s, a usual response was to take the first differences of each of the I(1) variables and then to use these first differences in any subsequent modeling process. In the context of univariate modeling (e.g. the construction of ARMA models), this is entirely the correct approach. However, when the relationship between variables is important, such a procedure is inadvisable. While this approach is statistically valid, it does have the problem that pure first difference models have no long-run solution. For example, consider two series, y_t and x_t , that are both I(1). The model that one may consider estimating is

$$\Delta y_t = \beta \Delta x_t + u_t$$

One definition of the long run that is employed in econometrics implies that the variables have converged upon some long-term values and are no longer changing, thus $y_t = y_{t-1} = y;\ x_t = x_{t-1} = x.$ Hence all the difference terms will be zero, i.e. Δy_t = 0; Δx_t = 0, and thus everything in the equation cancels. Model has no long-run solution and it therefore has nothing to say about whether x and y have an equilibrium relationship.

Fortunately, there is a class of models that can overcome this problem by using combinations of first differenced and lagged levels of cointegrated variables. For example, consider the following equation

$$\Delta y_t = \beta_1 \Delta x_t + \beta_2 (y_{t-1} - \gamma x_{t-1}) + u_t$$

This model is known as an error correction model or an equilibrium correction model, and $y_{t-1} - \gamma x_{t-1}$ is known as the error correction term. Provided that y_t and x_t are cointegrated with cointegrating coefficient γ, then $(y_{t-1} - \gamma x_{t-1})$

will be I(0) even though the constituents are I(1). It is thus valid to use OLS and standard procedures for statistical inference. It is of course possible to have an intercept in either the cointegrating term (e.g. $y_{t-1} - \alpha - \gamma x_{t-1}$) or in the model for Δy_t (e.g. $\Delta y_t = \beta_0 + \beta_1 \Delta x_t + \beta_2 (y_{t-1} - \gamma x_{t-1}) + u_t$ or both. Whether a constant is included or not could be determined on the basis of financial theory (Brooks, 2008, 337-338).

In this study, for the period between January 2013-January 2015, stock prices are tested for cointegration. All stock prices have unit root. To eliminate unit root, first difference of stock prices are used for analysis. Most traded six Turkish banks are paired with each other. Fifteen pairs are analyzed if they are cointegrated. After verifying all pairs are cointegrated, error correction model is estimated for each pair.

For pairs which can be estimated with error correction model are tested if they result in profit for trading period. Error correction model cannot be estimated only for one pair.

For fourteen pairs which error correction model can be estimated are tested if there is opportunity for pairs trading in the trading period. Coefficients are computed by regression on each pair in analyzing period. These coefficients are used for trading period. When error terms on trading period exceed +/-2 standard deviations in a pair on daily basis, this is perceived as a signal and pair position is opened on closing prices of Borsa Istanbul. Position is held for the number of trading days which error correction model indicates and closed on closing prices of Borsa Istanbul.

CHAPTER TWO
DATA AND ANALYSIS

2.1. DATA

The data used in this study comprise second session close of stock prices of Akbank, Garanti, Halk Bank, İş Bankası (C), Vakıfbank and Yapı Kredi Bankası which are traded in Borsa Istanbul between January 2013-January 2015. These stocks' instrument series codes are AKBNK, GARAN, HALKB, ISCTR, VAKBN and YKBNK respectively. These six banks account 20 % of total ISE total and 33 % of ISE 30 Index market value approximately. In data set corporate action effects on each stock are eliminated.

For the period between January 2013-January 2015 (will be called "analyzing period" hereinafter) 522 observations are used for analysis. After analyzing the data, trading results between February 1, 2015 and October 31, 2015 (which will be called "trading period" hereinafter) will be given. January 2015 is not a trading period in this study, because financial markets remain shallow especially during the first half of January every year, due to New Year and Christmas holidays. So during January volatility and trading volumes remain low in general and that causes loss in leveraged instruments like warrants which traders have to pay time value.

Trading results of stocks, out of the money (which will be called "OTM" hereinafter) and in the money (which will be called "ITM" hereinafter) warrants are given and compared. Additionally trading results of outperformance warrants are given for February 2015-August 2015.

For trading in stocks, bid-ask effect is not calculated, because, Borsa İstanbul introduced "closing session"[1] on March 2, 2012.

Unlike stocks, there is no "closing session"[2] for warrants which are traded in Borsa Istanbul. That's why warrant positions are opened at close of Borsa Istanbul

[1] Closing session is a special trading session operating with a single price, where the single price is calculated by transferring the unmatched orders (excluding quotation orders) entered in the main trading session, and accepting new orders in the trading system without matching in a pre-determined period of time, and determining the price level at which the highest trading volume (i.e., single price) may be achieved, and then all trades are realized at this price level.

with lowest ask price and closed on closing day with highest bid price. So, for warrants bid-ask effect is considered in this study.

Maturities of traded warrants are chosen from warrants whose expiration dates are the following month or the closest month. But the closest month's expiration date should be at least fifteen days because warrants which are very close to their expiration dates could make dramatic moves. Their value could be very close to zero. The possibility of these moves are tried to be eliminated.

As warrants which are traded in Borsa Istanbul are issued by only their issuers (brokerage firms), in rapidly changing market conditions, the possibility to find needed warrants could be limited. So, when there are no OTM or ITM warrants are listed for related underlying assets, warrants whose strike prices are closest to OTM or ITM are used in this study.

2.2. ANALYSIS

The steps described in this section are analyzing, trading and outperformance options-warrants. First, stocks which can be used in pairs trading are analyzed and their coefficients are computed in analyzing period. Then, trading results for trading period will be given. Finally outperformance options which are best fit financial instruments for this study are explained.

Banking industry is the most important sector in Borsa Istanbul. Banking sector is leading sector in terms of trading volume and market capitalization in Borsa Istanbul. Especially, six banks which are analyzed in this study approximately account 20 % percent of ISE Total and 33 % of ISE 30 Index market value. That's why warrants of these six stocks are launched by brokerage firms. Issuers of these warrants are also market makers in their issued warrants.

So, all paired stocks are chosen from same industry: "banking". This is very important for trading strategy because many risks are eliminated. The only risk on each pair is firm-specific risk. As these stocks have many common risks, it is expected that when a stock become overvalued or undervalued compared to another on a daily basis, these two stocks will have tendency to return to their long term mean and make an opposite move in short term.

[2] Warrants, exchange traded funds, rights coupons, and default transactions are not traded in the closing session (Closing Session, http://www.borsaistanbul.com/en/products-and-markets/markets/equity-market/closing-session, (28.02.2016)).

The presence of unit-root for the time-series data is checked through various procedures as a pre-condition. When these stocks' prices tested for unit root, all stock prices have unit root. That's why first differences are used to analyze stock prices. By using first differences of stock prices, unit root problem is eliminated. After cointegration test, error correction model is estimated and pair holding period for stocks and warrants will be examined with estimations of error correction model.

2.2.1. Cointegration and Error Correction

Table 1 shows t-statistics and probabilities of error terms which are calculated by stock price differences by using ordinary least square (OLS herein after) for each pair. The results show that all pairs which will be analyzed in this study are cointegrated.

Table 1: Augmented Dickey-Fuller Test Results

PAIR	COINTEGRATION t-STATISTICS	PROBABILTY
AKBNK-ISCTR	-25.549	0.000
AKBNK-YKBNK	-25.402	0.000
AKBNK-GARAN	-25.134	0.000
AKBNK-VAKBN	-24.742	0.000
YKBNK-GARAN	-23.985	0.000
VAKBN-ISCTR	-23.908	0.000
HALKB-VAKBN	-23.402	0.000
ISCTR-GARAN	-23.292	0.000
YKBNK-VAKBN	-23.198	0.000
YKBNK-ISCTR	-23.039	0.000
HALKB-AKBNK	-23.003	0.000
HALKB-YKBNK	-22.667	0.000
HALKB-ISCTR	-22.473	0.000
HALKB-GARAN	-21.635	0.000
VAKBN-GARAN	-20.924	0.000

After figuring out all pairs are cointegrated it is time to find which pairs can be estimated by error correction model. Table 2 shows that error correction can be estimated for 14 out of 15 pairs. In Table 2 error correction day corresponds to number of trading day each pair positions are held.

Table 2: Error Correction Model Results

PAIR	ERROR CORRECTION t-STATISTICS	ERROR CORRECTION DAY
YKBNK-ISCTR	-3.932	11
AKBNK-GARAN	-2.901	1
AKBNK-YKBNK	-2.230	5
YKBNK-VAKBN	-1.995	2
VAKBN-GARAN	-1.657	2
AKBNK-ISCTR	-2.920	6
VAKBN-ISCTR	-3.174	11
YKBNK-GARAN	-2.187	7
ISCTR-GARAN	-2.610	4
HALKB-GARAN	-1.878	4
HALKB-VAKBN	-2.508	6
HALKB-AKBNK	-1.857	3
HALKB-YKBNK	-2.281	7
HALKB-ISCTR	-2.125	11
AKBNK-VAKBN	-1.613	-

Only AKBNK-VAKBN pair cannot be estimated with error correction model. In Chapter 2.2 pair positions for stocks and warrants will be analyzed for fourteen pairs. Error correction day data will be used for number of trading days pairs will be held. So this data has a great importance for the success of trading because it will determine profit loss situation of each pair.

2.2.2. Trading Analysis

OLS regression is used to calculate coefficients of each pair in analyzing period. There is no constant term included in model because all constant terms are statistically insignificant and Dunis (2010) mentioned, “when the price of one share goes to 0, why would there be any threshold level under which the price of the second share cannot fall?”. Additionally these six banks are very strong banks and their defaults risk can be negligible for this analysis, because pair positions are held for very short time.

Estimations of error correction model are used to find number of trading days to hold pair positions. In Table 2, it is shown how many trading days each pair position is held. These numbers of trading days are calculated by error correction model whose t-statistics are highest as absolute value and significant under 90 % confidence level and the coefficient sign of errors should be negative.

By using OLS regression, mean value of error terms and coefficients of pairs are computed in analyzing period. These values are used for creating a signal in trading period. When the error terms in trading period exceed 2 standard deviations above or below their mean value in analyzing period on daily basis, pair position is opened. Long position is opened in relatively undervalued stock and short position is opened in relatively overvalued stock. Long and short position are opened on same volume in terms of Turkish Lira. There is no position opened when there is a dividend payment in a paired stock.

Pair positions are opened in stocks, OTM and ITM warrants. Profit/loss results of pairs for each financial instrument will be given in next steps.

The average cost of trading in stocks and warrants is approximately 0.1 %. All pair positions are opened and then closed. So the average cost for transaction could be considered as 0.2 %. This cost could be some important for stock returns because of being lower when compared to warrant returns. But in all stock pairs which result in positive return still make positive return when trading costs are deducted. That's why trading costs are neglected in the study.

2.2.2.1. Pairs Trading in Stocks

In trading period, coefficients which are calculated for the period 2013-2014 is used as a trading signal. Regressions are built for all pairs and pair positions are opened when the error terms exceed 2 standard deviations above or below their mean value for the period 2013-2014. In Table 3 the following can be seen,

- number of deviations (how many times pair positions are opened),
- number of days pair position held (which is derived from error correction model),
- average profit per transaction as percentage (total profit divided to number of deviation),
- daily average profit as percentage (average profit per transaction divided to number of positions held),

- annualized daily average profit as percentage (daily average profit multiplied by 250 which is used trading day per a year for this study).

In four pairs there is no chance for pairs trading. That means error terms in trading period don't exceed 2 standard deviations above or below their mean value for analyzing period. That's why there is no calculation for these four pairs.

In trading period, when traded with stocks according to the rules set in this study, two tenth of traded pairs result in loss and eight tenth of traded pairs result in profit.

Table 3: Stock Trading Results

Pair	Number of Deviations	Number of Days Pair Position Held	Average Profit per Transaction (%)	Daily Average Profit (%)	Annualized Daily Average Profit (%)
YKBNK-ISCTR	7	11	0.90	0.08	20.46
AKBNK-GARAN	3	1	0.35	0.35	86.79
AKBNK-YKBNK	4	5	-0.55	-0.11	-27.51
YKBNK-VAKBN	5	2	0.51	0.26	64.28
VAKBN-GARAN	3	2	0.56	0.28	70.48
AKBNK-ISCTR	3	6	1.47	0.25	61.40
VAKBN-ISCTR	2	11	-0.90	-0.08	-20.42
YKBNK-GARAN	1	7	1.35	0.19	48.29
ISCTR-GARAN	2	4	0.98	0.24	61.22
HALKB-GARAN	1	4	0.87	0.22	54.09
HALKB-VAKBN	-	6	-	-	-
HALKB-AKBNK	-	3	-	-	-
HALKB-YKBNK	-	7	-	-	-
HALKB-ISCTR	-	11	-	-	-

2.2.2.2. Pairs Trading in OTM Warrants

Pair positions are opened in warrants in the same trading day with stocks. In this chapter pair position on OTM warrants will be analyzed.

In Table 4 the results of trading with OTM warrants are given. According to the trading results, five tenth of traded pairs make loss and five tenth of traded pairs make profit. Number of pairs result in profit decrease with OTM warrant relative to stocks from eight to five. The reason of this situation could be bid-ask spread effect and time value effect in warrants[3].

[3] Warrants may be traded on Borsa İstanbul provided that they are supported through market making activity by their issuers or the brokerage companies contracted by the issuers. In order to provide a liquid and well-regulated market, the market maker is required to give quotations continuously (Warrants, http://www.borsaistanbul.com/en/products-and-markets/products/warrants, (02.03.2016)).

Table 4: OTM Warrants Trading Results

Pair	Number of Deviations	Number of Days Pair Position Held	Average Profit per Transaction (%)	Daily Average Profit (%)	Annualized Daily Average Profit (%)
YKBNK-ISCTR	7	11	- 10.10	- 0.92	- 229.45
AKBNK-GARAN	3	1	0.16	0.16	40.00
AKBNK-YKBNK	4	5	-17.64	-3.53	-881.94
YKBNK-VAKBN	5	2	-4.77	-2.39	-596.63
VAKBN-GARAN	3	2	5.70	2.85	712.50
AKBNK-ISCTR	3	6	22.73	3.79	947.15
VAKBN-ISCTR	2	11	-39.65	-3.60	- 901.02
YKBNK-GARAN	1	7	-11.54	-1.65	-411.96
ISCTR-GARAN	2	4	7.30	1.83	456.25
HALKB-GARAN	1	4	2.10	0.53	131.25
HALKB-VAKBN	-	6	-	-	-
HALKB-AKBNK	-	3	-	-	-
HALKB-YKBNK	-	7	-	-	-
HALKB-ISCTR	-	11	-	-	-

2.2.2.3. Pairs Trading in ITM Warrants

Pair positions are opened in ITM warrants in the same trading day with stocks and OTM warrants. So profit/loss results for stocks, OTM warrants and ITM warrants could be compared. In this chapter pair position on ITM warrants will be analyzed.

In Table 5 the results of trading with ITM warrants are given. According to trading results, three tenth of traded pairs result in loss and seven tenth of traded pairs result in profit. Number of pairs result in profit decrease with ITM warrant from eight to seven compared to stocks but it increased compared to OTM warrants from five to seven.

Table 5: ITM Warrants Trading Results

Pair	Number of Deviations	Error Correction Day	Average Profit per Transaction (%)	Daily Average Profit (%)	Annualized Daily Average Profit (%)
YKBNK-ISCTR	7	11	-4.82	-0.44	- 109.64
AKBNK-GARAN	3	1	3.73	3.73	931.67
AKBNK-YKBNK	4	5	-15.45	-3.09	-772.25
YKBNK-VAKBN	5	2	2.65	1.32	331.13
VAKBN-GARAN	3	2	8.18	4.09	1,022.92
AKBNK-ISCTR	3	6	23.22	3.87	967.36
VAKBN-ISCTR	2	11	-21.44	-1.95	- 487.27
YKBNK-GARAN	1	7	5.12	0.73	182.86
ISCTR-GARAN	2	4	0.77	0.19	48.28
HALKB-GARAN	1	4	3.59	0.90	224.06
HALKB-VAKBN	-	6	-	-	-
HALKB-AKBNK	-	3	-	-	-
HALKB-YKBNK	-	7	-	-	-
HALKB-ISCTR	-	11	-	-	-

2.2.2.4. Comparison of Stocks, OTM and ITM Warrants in Trading Period

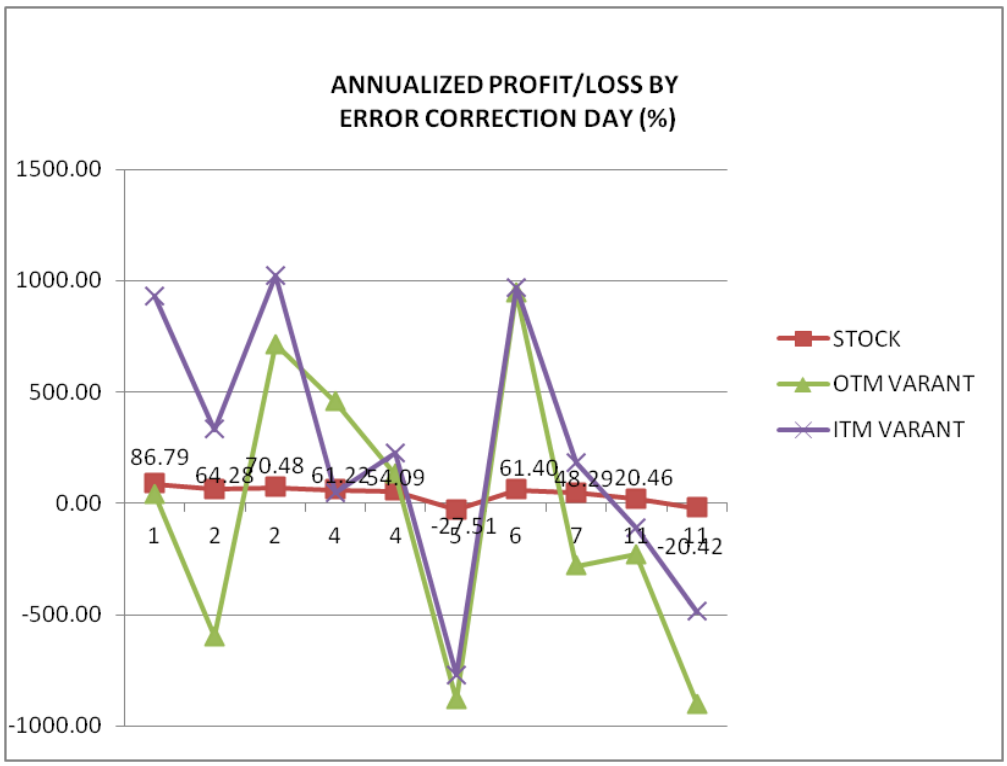
In this part, profit/loss results of stocks, OTM and ITM warrants will be given and compared. Reasons of the results are tried to be figured out.

Trading with stocks is an easy way for pairs trading in terms of calculation. But short selling is a bit difficult because you need to borrow stocks from the owner. Traders can't often find opportunity to borrow stock in Borsa Istanbul. So we can use derivatives for our paired stocks.

In Borsa Istanbul the most developed derivative market for single stocks are warrants. Other opportunities are options and single stock futures. Single stock futures and options market's trade volume is very low. It is difficult to find needed options and futures on good bid ask spread. So, in this study warrants are used for pairs trading.

In trading with stocks, eight pairs result in profit while two pairs result in loss. Number of pairs result in profit ITM warrants are seven and OTM warrants are five.

Figure 1: Annualized Returns by Error Correction Day



In Figure 1 above, the labels of annualized stock profit/loss results are showed in percentage because they are very close to axis and cannot be easily recognized. It can be noticed that returns on warrant pairs are negatively affected as the error correction day increases (pair holding day). The reason of this situation is the time value paid for warrants.

In Table 6 total profit/loss situation for the trading period can be seen. Even in ITM and OTM warrants result in losses, if there were no position opened for five and more days, these losses would be erased and turned to profit.

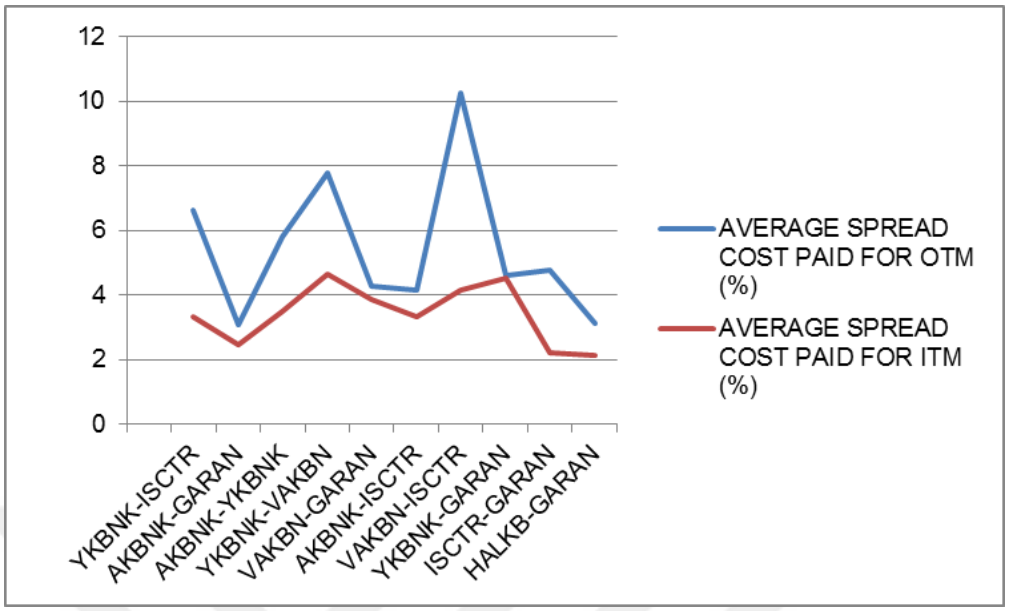
Table 6: Total Profit/Loss on Trading Period and Effect of Time Value

	Total Return (%)	**Annualized Return (%)**	**Five and more days excluded Return (%)**	**Five and more days excluded Annualized Return (%)**
Stock	16.20	23.15	-	-
OTM Warrant	-153.44	-219.20	10.42	83.99
ITM Warrant	-9.56	-13.65	54.11	436.33

As warrants cannot be sold (written) by traders while opening position, traders have to pay time value for warrants. The longer time holding period takes, the more costly warrants will be for investors.

Another result that can be easily noticed in Figure 1 is ITM warrants perform better than OTM warrants. This situation is valid for all ten pairs. In fact, OTM warrants are more leveraged financial instruments and they are expected to make more profit when stock pairs result in profit. On the contrary, two pairs in ITM warrants result in profit while OTM warrants result in loss. The reason of better performing of ITM warrants compared to OTM warrants is explained in Figure 2.

Figure 2: Average Spread Cost Paid for ITM and OTM Warrants



Average spread cost paid for ten pairs in ITM warrants is 3.42 % while this cost for OTM warrants is 5.45 %. This makes ITM warrants perform better than OTM warrants.

The relationship between spread cost paid and warrant return can be seen on Figure 3. and Figure 4. Axis of Figure 3 and Figure 4 show the average spread cost paid for warrants (OTM in Figure 3 and ITM in Figure 4) as percentage of warrant prices. They are also compared with spread cost paid for stocks in Figure 3 and Figure 4.

Figure 3: Average Profit per Transaction for Stock vs. OTM Warrant

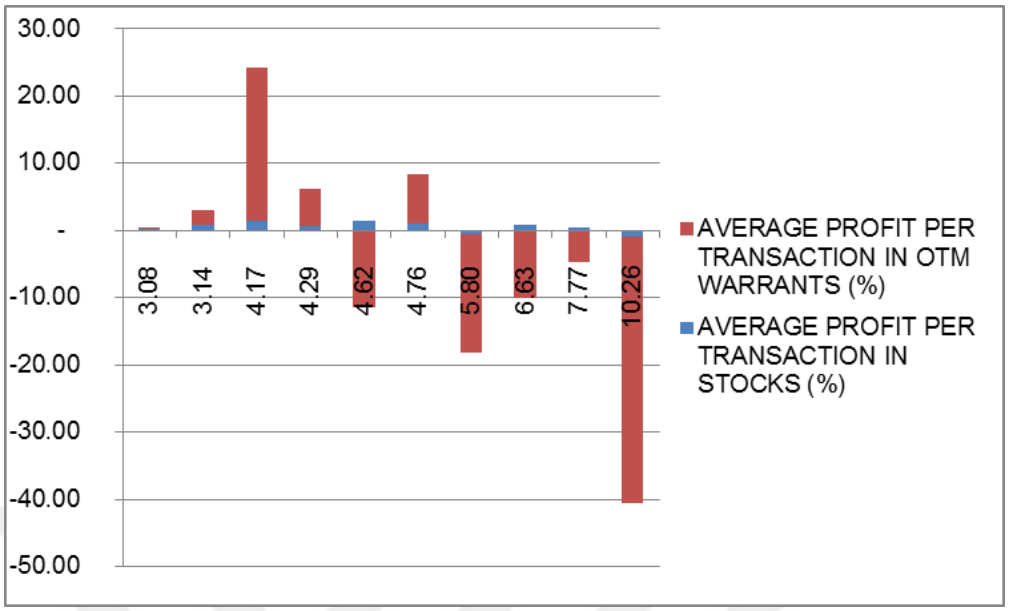
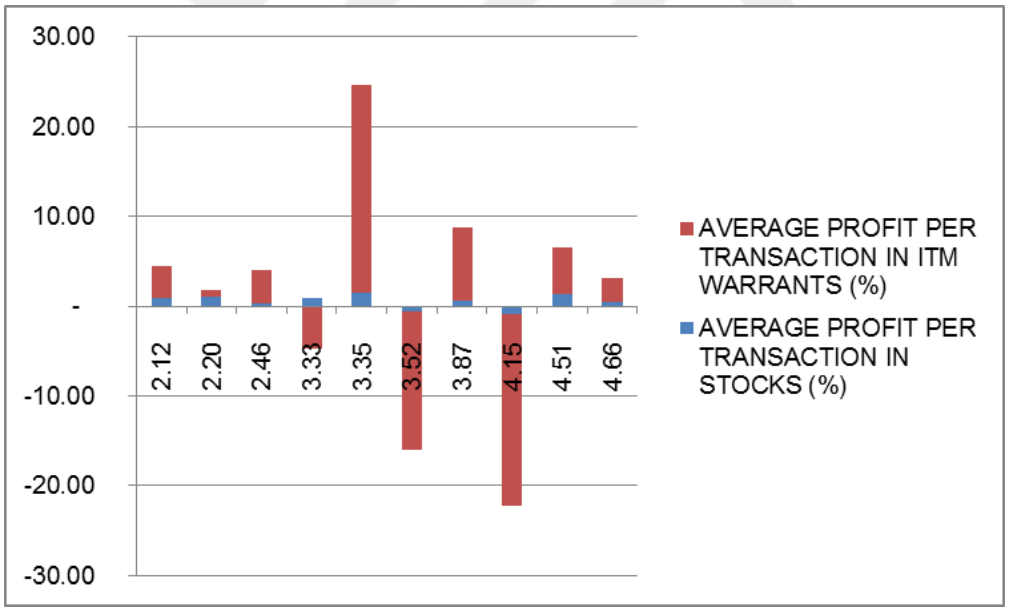


Figure 4: Average Profit per Transaction for Stock vs. ITM Warrant



In Figure 3 and Figure 4, as the average spread cost paid for warrants exceeds 5 %, pairs which make profit in stocks; make loss in OTM warrants. The average spread cost paid for ITM warrants are under 5 % and their profit/loss situation are generally consistent with stocks.

Table 7: Effect of Bid-Ask Spread on Returns

Pair	Average Profit per Transaction (%)	Average Spread Cost Paid For OTM (%)	Average Spread Cost Paid For ITM (%)	Average Profit per Transaction In OTM Warrants (%)	Average Profit per Transaction In ITM Warrants (%)
YKBNK-ISCTR	0.90	6.63	3.33	-10.10	-4.82
HALKB-GARAN	0.87	3.14	2.12	2.10	3.59

In Table 6 the effect of spread cost is very remarkable. In HALKB-GARAN pair average profit per transaction for stocks is 0.87 % and in YKBNK-ISCTR pair this value is 0.90 %. Although average profits per transaction for two pairs are very close values, their ITM and OTM warrant returns are very different and even in different sign. The reason of these results is the average spread cost paid for OTM and ITM warrants' differentiation.

2.2.3. Outperformance Options-Warrants

Outperformance option measures the outperformance, whether it be on the upside or downside, of one stock against another and pays this difference. Obviously, an outperformance option can also be structured between two different assets, like a stock and the oil price, in which case it measures the outperformance of the stock against the oil price. The beauty of outperformance options is that their pricing and risks look complicated but can easily be understood when comparing them to a composite option. The next sub-section gives an example of an outperformance option.

To look at the outperformance option on two stocks is to say that one is allowed to swap the stock the investor thinks will underperform for the other stock in the ratio of the two stock prices at inception of the trade.

The more inversely correlated the two stocks in the outperformance option are, the more valuable is this outperformance option. This is intuitive as the holder of an outperformance option stands to receive the highest payout if the two stocks

move in opposite directions, i.e. the outperforming stock moves up and the other stock moves down (De Weert, 2008:129-130).

In Borsa Istanbul, Is Yatirim launched outperformance warrants in 2014. But as of September 2015 there is no outperformance warrant listed in Borsa Istanbul for trading period. Trading period of this study is between February 1, 2015 and October 31, 2015. That's why trading analysis for outperformance warrants is made for February-August 2015 period.

The outperformance ("OPM" hereinafter) warrants listed in Borsa Istanbul were:

- GARAN / AKBNK
- PGSUS [4]/ THYAO[5]
- ISCTR / GARAN
- HALKB / VAKBN
- KCHOL[6] / SAHOL[7]
- GARAN / EREGL[8]
- AKBNK / YKBNK
- GARAN / YKBNK

Five of these OPM warrants can be our underlying assets for trading. But for HALKB / VAKBN OPM warrant there is no chance for pairs trading as mentioned before. So there are four OPM warrants which can be traded in trading period.

The underlying assets of launched OPM warrants are consistent with this study. All paired stocks are from same industry such as banking, aviation and holding.

In Table 7 results of OPM warrants whose underlying assets are pairs in this study are shown. According to trading results, two fourth of traded pairs result in loss, one fourth of traded pairs results in profit and one pair result in neither profit nor loss.

[4] Pegasus Airlines

[5] Turkish Airlines

[6] Koç Holding

[7] Sabancı Holding

[8] Ereğli Demir Çelik

Table 8: Outperformance Warrants Trading Results

Pair	Number of Deviations	Error Correction Day	Average Profit per Transaction (%)	Daily Average Profit (%)	Annualized Daily Average Profit (%)	Average Spread Cost Paid for OPM (%)
AKBNK-GARAN	1	1	0.00	0.00	0.00	8.33
AKBNK-YKBNK	3	5	- 42.14	- 8.43	- 2,107.17	8.47
YKBNK-GARAN	1	7	- 50.00	- 7.14	- 1,785.71	66.67
ISCTR-GARAN	2	4	14.29	3.57	893.13	8.62

In YKBNK/GARAN OPM warrant, average spread cost is 66.67 % of warrant price. The reason of this situation is this outperformance warrant is deep out of the money. So, this cost causes % 50 loss in trading.

The reason of that much spread cost is that, there is no other expiration dates for traded OPM warrants. So in this OPM trading, because of only one warrant is listed with an expiry date, deeply out of money OPM warrant is traded and the result is huge loss.

If there were enough liquidity and volume in outperformance warrants for pairs, it would have been better to trade in outperformance warrants instead of buying two different call and put warrants in this study because of paying less bid ask spread cost and trading cost.

CONCLUSION

The aim of this study is introducing a new perspective to traders for pairs trading by using leveraged instruments. The data is second session close of stock prices of Akbank, Garanti, Halk Bank, İş Bankası (C), Vakıfbank and Yapı Kredi Bankası on daily basis. Co-integration and error correction model are applied to these bank stocks which are traded on Borsa İstanbul.

All stocks are paired with each other and fifteen pairs are formed. All pairs are co-integrated which means that these stocks are in long run equilibrium. Then error correction model is applied to all pairs and fourteen pairs out of fifteen can be estimated with error correction.

Subsequently, coefficients which are calculated in analyzing period are applied to trading period to create trading signals on daily basis. When error terms exceed the confidence interval (+/-2 standard deviations above or below their mean value daily) pair position is opened. That means long position is opened in relatively undervalued stock and short position is opened in relatively overvalued stock, on same volume in terms of Turkish Lira. Pair positions are held for the number of trading days which error correction model estimates.

Then pair positions are held in stocks, OTM warrants and ITM warrants. The results of these positions are examined. The results show that OTM and ITM warrants both result in higher profit or loss compared to stocks by using leverage. Another result is when pairs holding-day number increases, time value paid for warrants increases and spirit off the pairs' profit.

Final result is ITM warrants perform better than OTM warrants. The reason of this better performing of ITM warrants is average spread cost paid for ITM warrants are significantly less than OTM warrants. There is no bid ask spread effect on stocks trading because of closing session in Borsa İstanbul.

To conclude, in this study a new approach is tried to be shown for pairs trading. The pairs are held for the period which error correction model estimates. Results of stock, OTM warrant and ITM warrant pairs trading are calculated and compared. The factors affecting trading results are examined in a detailed manner.

Another proposal for further research is pairs trading with options. Options contracts can be sold (written) by retail traders while opening position, that's why traders don't have to pay time value pairs trading on options different from warrants.

So the duration to hold pair position will extend and traders will have more chance to hold positions on two instruments which are deviated from long run equilibrium.

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