

## *The Secret to Cash the Profits in Pair Trading Strategies: A Case Of KSE Firms*

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### ABSTRACT

#### Keywords:

Pair trading,  
Co-integration  
PSX, Jensen.

One of the profitable strategies in construction of portfolio is pair trading strategy. To capture the profitability through pair trading, co-integration approach is used in this study. The formation of pairs take place from three sectors textile, chemical and banking using the daily data from year 2011 to year 2019. Different parameterizations are used for trading system algorithm. Positive and significant returns are generated from co-integration approach. Further, positive risk adjusted returns are also be observed in all the three sectors. The results also validate the market neutrality, mean revision and challenge to EMH. Investors and fund managers can get positive risk adjusted returns while applying pair trading strategies at PSX.

### INTRODUCTION

Pakistan Stock Exchange (PSX) ex KSE was established 18-09-1947 after the few days of independence. Later on, other exchanges were also established at Lahore and Islamabad. After demutualization, only one exchange is now operational from 11-01-2016 known as PSX. The regulatory body of PSX is Securities and Exchange Commission of Pakistan. Stock exchanges play vital role in economy of any country. PSX also helping to boost the economy of Pakistan. Different strategies are adopted by investors to get positive returns. Amongst these strategies, one of the prominent strategies is pair trading.

In pair trading strategy, two financial assets (stocks etc.) are selected to observe the long-run co-movements. If there exist such relation, long position is taken for under-priced stocks, short position is taken for over-priced stocks (Vidyamurthy, 2004). As a result, statistical arbitrage opportunity emerges due to deviations from long-run relationship of pairs. Different methodologies are used in pair formation; like; price ration, co-integration, Price ratio and correlation (Krauss & Christopher, 2015), Each

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methodology has its own advantages and disadvantages. In pair trading strategies market timing is also important to decide for short or long positions (Charles & Darné, 2009). When prices of pair converge as according to their long-run relationship, profitability is generated by the investors. So this strategy also follows mean reversion theory (Gatev, Goetzmann, & Rouwenhorst, 2006). One of the major critiques faced by EMH is mean revision theory. On the other hand, one of the major costs is transaction cost, whereby, profitability is usually reduced (Kanamura, Svetlozar, & Frank, 2011).

In some pair trading strategies different approaches are used. Constraints on disagreements in the case of different priors and common beliefs have also been driven and reported in the study of (Gizatulina & Hellman, 2019). A novel two-stage methodology has been used to investigate the experiential factors of the ex post impacts of past free trade agreements. Their results revealed that FTA impacts were not strong for more distant pairs (Baier, Yotov, & Zylkin, 2019). Bowen & Hutchinson (2016) focused on high frequency data and reported studies excess returns of portfolios of pair trading. However, they also pointed out sensitivity of return with regard to transaction cost and some other factors. In the same line Jacobs & Weber (2015) also reported profitability of pair trading portfolios and discussed some additional factors like interaction of news, investor attention, and limitation of arbitrage process.

The pair trading strategies are mostly used by hedge funds in 1980s and still these strategies are used (Nicholas, 2004). Tartaglia's group and Bamberger are said to be pioneers of the usage of pair-trading strategies (Gatev, Goetzmann, & Rouwenhorst, 2006). One of the prominent advantages of pair trading strategy is that it always gives profits in any market conditions that is it follows "market neutral" (Kanamura, Svetlozar, & Frank, 2011).

Miao (2014) uses high frequency data and reported 56.58 percent cumulative returns under cointegration approach. Tsoku and Moroke. (2018) used data of JSE and preferred co-integration approach. But their study was limited to only 18 pairs. Zhang and Urquhart (2019) used the data of highly liquid midcap and large-cap firms for a year and concluded that pair trading is still profitable after adjusting risk and transaction cost and yielded abnormal return of 9 percent across Mainland China and Hong Kong. According to Krauss (2017), five pair trading strategies are dominant; these are stochastic differentials, correlation, stochastic distance, and co-integration. In line with the study of Krauss (2017), Blázquez and Román (2018) also used these methodologies to compare the profitability of pair trading and

preferred co-integration approach. Further, Ramos-Requena, Trinidad-Segovia, and Sánchez-Granero. (2020) have comprehended the different methodologies (correlation, distance, Hurst and cointegration) for pair selection.

However, in all these methodologies the parameterization of standard deviations was 1.5 and 2. However, in some studies although 2.5 standard deviation as a one parameter is also used but the formation period was just six months. Therefore, it is needed to enquire the matter more precisely by adopting one formal procedure. For this purpose, this study will compare and contrast the results of pair trading strategy under different parametrization and formation period of pair selection by taking one-year period. This study will also take the risk adjusted performance as well.

In Pakistan' context, Qazi, Rehman and Gul (2009) is the only study in Pakistan where the pair formation strategy is discussed, however, their study lack the actual trading of the pair. As a result, there is no evidence of profitability of pair trading at PSX.

### **Problem Statement**

To enquire the matter of pair trading strategy, more precisely to follow one formal procedure, this study will compare and contrast the results of pair trading strategy under different parametrization and formation period of pair selection by taking one-year period. Further as no single study exists in Pakistan regarding pair formation and trading of pairs. Therefore, this study will also investigate a different range of parameterization to calculate the profitability of portfolios in pair trading strategies. In addition, the risk adjusted performance will also be investigated.

The current study focuses on profitability of pair trading as the strategy at PSX. Therefore, main objectives of this study are:

1. Does co-integration approach give profitability in pair trading strategies?
2. In case of sector analysis, which sector provides higher profitability?
3. What is the risk adjusted performance profitability in pair trading strategies?

As discussed earlier, different methodologies are used in pair formation; like; price ration, co-integration, distance approach, copulas. Each methodology has its own advantages and disadvantaged.

For example, copulas are used to observe relationship of pairs for shorter period, while in co-integration approach, longer period is required. Therefore, in this study, as formation period for pairs selection is of

12 months, so co-integration approach is applied. From this study investors and fund managers can get positive risk adjusted returns while applying pair trading strategies.

## **LITERATURE REVIEW**

In 1980, pair trading strategies were used and specially these strategies were mostly used by hedge fund managers. The literature review of pair trading strategies would be incomplete if someone overlook the study of Gatev et al. (2006). In this study data from year 1962 to year 2002 was used to observe the profitability in USA under the umbrella of pair trading. He reported on average 11% rate of return annually. However, some researchers have point of view that a handsome profit of profitability of pair trading were reduced due to transaction cost (Lei & Xu, 2015). On the other hand, the pair trading strategy is profitable while taking transaction cost (Gatev et al., 2006).

Although in the literature different approaches are used for formation of pairs however, amongst these approaches the co-integration approach can be considered to be the best one (Vidyamurthy, 2004). The profitability of pair trading strategy is reported by (Vidyamurthy, 2004) by using this co-integration approach in 2004 and he linked the Arbitrage Pricing Theory of (Ross, 1976). As literature is evident that irrespective of different approach used for pair formation, pair trading approach is profitable, like Mori and Ziobrowski (2011) reported profitability while using distance approach and reported profitability in pair trading. In the same way Smith and Xu (2017) reported profitability by using distance approach. The distance approach is also applied by Nath (2003), Yuksel (2010) and Daeves & Ehrhardt (2016). In all these studies excess returns of portfolios of pair trading have been reported. Nevertheless, another approach that is VECM is used by Ferretti, Paraskevopoulos, and Tang (2018) and also witnessed with the positive returns in pair trading strategy.

There are numerous studies that report profitability in pair trading strategies like the most recently by the study of Namwong, Yamaka, & Tansuchat (2019) that is conducted in Thailand. Some factors like interaction of news, investor attention, and limitation of APTs are discussed in pair trading by Jacobs &

Weber (2015) and they also reported profitability. Bowen & Hutchinson (2016) also reported profitability by using high frequency data. Schmidt (2008) validate the mean reversion theory in pair trading strategy. Further the study of Fung & Hsieh (1999) is about risk under pair trading and he cape with the results that risk is different.

In some studies, pair trading is categorized with reference to use of different methodologies like “the distance approach (Gatev et al., 2006), Stochastic spread (Elliott, Van Der Hoek, et al., 2005), stochastic residual spread (Do & Faff, 2010) and co-integration approach (Liew & Wu, 2013)”. In these studies co-integration methodology is used with reference to some technical aspects; (Paul & Vaihekoski, 2012), (H. Puspaningrum, Y. X. Lin, 2009), (Vidyamurthy, 2004), Lin, Mccrae, & Gulati (2006), Caldeira & Moura (2013), Galenko, Popova, & Popova (2012, and (Krauss & Christopher, 2015). In some studies, comparative results were discussed by applying various mythologies like Caldeira & Moura (2013), Lin et al. (2006), Liew & Wu (2013), Hong & Susmel (2003), and Basher & Sadorsky (2016).

Miao (2014) use high frequency data and reported 56.58 percent cumulative returns under cointegration approach. Tsoku and Moroke. (2018) used data of JSE and preferred co-integration approach. But their study was limited to only 18 pairs. Zhang and Urquhart (2019) used the data of highly liquid midcap and large-cap firms for year and concluded that pair trading is still profitable after adjusting risk and transaction cost and yielded abnormal return of 9 percent a across Mainland China and Hong Kong.

According to Krauss (2017), five pair trading strategies are dominant; these are stochastic differentia, correlation, stochastic, distance, and co-integration. In the line with the study of Krauss (2017), Blázquez and Román (2018) also used these methodologies to compare the profitability of pair trading and preferred co-integration approach. Further, Ramos-Requena, Trinidad-Segovia, and Sánchez-Granero. (2020) have comprehended the different methodologies (correlation, distance, Hurst and cointegration) for pair selection. Whatever the methods for pair trading formation period, the pair trading is came with positive return for investors. So, this study also expects positive returns and therefore the hypothesis of this study are:

H<sub>1</sub>: Abnormal returns of different pairs trading portfolios under different parameterization are positive.

H<sub>2</sub>: Jensen's alpha of abnormal returns of different pairs trading portfolios under different parameterization are positive

### METHODOLOGY FOR THE STUDY

In this study three sectors are taken, where 16 companies are selected based on market capitalization. Nine years daily data is used from 2011-2019. After formation period of pairs for one year, stocks are traded for half year period. The program for trading is written in visual Basic in alignment with Excel. Under co-integration methodology, prospect pairs are considered have same order of integration. The spread of prospect pairs are calculated as:

$$\Delta P R_t^{ij} = \log ( P_t^i / P_t^j ) \quad .1$$

ADF test is applied for mean reversion as by running the regression:

$$\Delta P R_t^{ij} = \beta P R_{t-1}^{ij} + \varepsilon_t. \quad .2$$

The rejection of hypothesis  $\gamma = 0$  would lead to validation of reverting of spread to mean. Then co-integration is tested by methodology of Johansen co-integration. As a result, large numbers of pairs are formed. Two-way granger causality is also applied. For selection of top 20, 15, 10 and 5 pairs portfolio, market factor spread (MFS) are calculated based on lowest spread. After selection of top pairs in the formation period, trading of stocks would take place for the period of six months. The pair's spread is calculated and compared with trigger value as discussed below. Trading would remain open when spread remain greater than trigger. Long position is taken for the lower price and short position for the higher priced stocks.

$$\text{Abs} ( P_t^i - P_t^j ) \geq \text{trigger} ( i , j ) \quad .3$$

where  $\text{Trigger} ( i , j ) = n \times \text{SD} ( i , j )$  and  $n=2$ .

$$\text{SD} ( i , j ) = \sqrt{ \frac{1}{Tfp-1} \sum_{t=1}^{Tfp} [(P_t^i - P_t^j)^2 - Di,j]^2 } \quad .4$$

A trading would remain open if equation 3 satisfied and would close if the spread of normalized price reverts to non-positive value. In this study trigger values are 1.5, 2.0, 2.5. The daily returns under the methodology of (Gatev et al., 2006) are calculated as

$$R_t(p^k) = R_t(l^k) - R_t(s^k). \tag{.5}$$

Therefore, for  $N_t^*$  pairs of top 20, 15, 10 and 5 portfolios, daily returns are calculated on equally weighted ( $=W_t^k$ ) basis as mentioned below.

$$R_t^{port} = \sum_{k=1}^{N_t^*} W_t^k R_t(p^k) \tag{.6}$$

The risk adjusted performance is calculated by CAPM

$$\text{Excess\_Ret}_{Ft} = a_i + b_i (R_{Mt} - R_{Ft}) + \epsilon_{it} \tag{.7}$$

## RESULTS AND FINDINGS

After the formation of top 20, 15, 10 and 5 portfolios of pairs, the descriptive analysis of all the three sectors are followed by quantitative analysis. These results are discussed under different parametrizations to check whether these results are different or not under these parameterizations.

### *Descriptive Analysis*

The results of descriptive analysis of all the three sectors; banking, chemical and textile are displayed in Table 1 to 3 respectively. In banking sector, the average values under different parametrizations of standard deviations 1.5, 2 and 2,5 are found to be positive. Conforming the profitability of pair trading strategy in PSX. The highest average returns of 0.0839 are to be observed if portfolio consists of top 5 pairs under trigger valued of 2.5. However, the volatility is also maximum for this top 5 portfolio pairs. These results are with accordance to prior studies of pair trading like (Lei & Xu, 2015), Namwong, Yamaka, & Tansuchat (2019) and Smith and Xu (2017) etc.

**Table-1**

Sector: Banking	Top-20-Pairs			Top-15-Pairs		
Formation Period as Parameter A	1-Year (daily data of 1-year for each parameter B)					
Trigger as Parameter B	1.5	2	2.5	1.5	2	2.5

Min. Values	-0.0076	-0.0282	-0.0157	-0.0211	-0.0212	-0.0230
Max. Values	0.1750	0.1954	0.8661	0.2338	0.2633	1.1501
Avg. Values	0.0292	0.0451	0.0606	0.0400	0.0565	0.0673
Med. Values	0.0288	0.0291	0.0377	0.0417	0.0416	0.0381
Std. Deviations	0.0323	0.0312	0.1054	0.0358	0.0482	0.1182
Sector: Banking	Top-10-Pairs			Top-5-Pairs		
Formation Period as Parameter A	1-Year (daily data of 1-year for each parameter B)					
Trigger as Parameter B	1.5	2	2.5	1.5	2	2.5
Min. Values	-0.0229	-0.0463	-0.0251	-0.0951	-0.1159	-0.0966
Max. Values	0.2862	0.3695	1.7178	0.3988	0.7401	3.3952
Avg. Values	0.0349	0.0478	0.0578	0.0458	0.0646	0.0839
Med. Values	0.0297	0.0193	0.0357	0.0278	0.0264	0.0359
Std. Deviations	0.0514	0.0663	0.1824	0.0740	0.1336	0.3682

Similarly, in chemical sector, the average values under different parametrizations of standard deviations 1.5, 2 and 2,5 are found to be positive. Conforming the profitability of pair trading strategy in PSX. The highest average returns of 0.0646 are to be observed if portfolio consists of top 10 pairs under trigger valued of 2. Again, the volatility is also second highest for this top 10 portfolio pairs. These results are with accordance to prior studies of pair trading like (Lei & Xu, 2015), Namwong, Yamaka, & Tansuchat (2019) and Smith and Xu (2017) etc.

**Table-2**

Sector: Chemical	Top-20-Pairs			Top-15-Pairs		
Formation Period as Parameter A	1-Year (daily data of 1-year for each parameter B)					
Trigger as Parameter B	1.5	2	2.5	1.5	2	2.5
Min. Values	-0.0170	-0.0055	0.0007	-0.0278	-0.0024	-0.0117
Max. Values	0.2106	0.5896	0.5924	0.2056	0.7107	0.7572
Avg. Values	0.0299	0.0482	0.0515	0.0332	0.0546	0.0464
Med. Values	0.0155	0.0198	0.0210	0.0167	0.0276	0.0185
Std. Deviations	0.0365	0.1045	0.1054	0.0400	0.1349	0.1369
Sector: Chemical	Top-10-Pairs			Top-5-Pairs		
Formation Period as Parameter A	1-Year (daily data of 1-year for each parameter B)					
Trigger as Parameter B	1.5	2	2.5	1.5	2	2.5
Min. Values	-0.0219	-0.0039	-0.0050	-0.0302	-0.0446	-0.0064



Max. Values	0.1616	1.0321	1.1455	0.0849	0.3701	0.1418
Avg. Values	0.0222	0.0646	0.0538	0.0012	0.0188	0.0020
Med. Values	0.0177	0.0165	0.0152	0.0012	-0.0041	-0.0016
Std. Deviations	0.0385	0.1843	0.2052	0.0179	0.0556	0.0170

For textile sector, the average values under different parametrizations of standard deviations 1.5, 2 and 2,5 are found to be positive. Conforming the profitability of pair trading strategy in PSX. The highest average returns of 0.1134 are to be observed if portfolio consists of top 5 pairs under trigger valued of 2. However, the volatility is also maximum (0.4) for this top 5 portfolio pairs. These results are with accordance to prior studies of pair trading like (Lei & Xu, 2015), Namwong, Yamaka, & Tansuchat (2019) and Smith and Xu (2017) etc.

**Table-3**

Sector: Textile	Top-20-Pairs			Top-15-Pairs		
Formation Period as Parameter A	1-Year (daily data of 1-year for each parameter B)					
Trigger as Parameter B	1.5	2	2.5	1.5	2	2.5
Min. Values	-0.0083	0.0000	-0.0122	-0.0075	-0.0164	-0.0091
Max. Values	0.3004	1.4572	1.4463	0.3901	0.7465	0.7423
Avg. Values	0.0427	0.0844	0.0773	0.0419	0.0692	0.0574
Med. Values	0.0160	0.0243	0.0222	0.0113	0.0262	0.0081
Std. Deviations	0.0535	0.2651	0.2420	0.0665	0.1407	0.1439
Sector: Textile	Top-10-Pairs			Top-5-Pairs		
Formation Period as Parameter A	1-Year (daily data of 1-year for each parameter B)					
Trigger as Parameter B	1.5	2	2.5	1.5	2	2.5
Min. Values	-0.0128	-0.0235	-0.0135	-0.0149	-0.0376	-0.0267
Max. Values	0.5710	1.1207	1.1137	0.6450	2.1770	2.1875
Avg. Values	0.0578	0.0927	0.0869	0.0515	0.1134	0.0996
Med. Values	0.0165	0.0229	0.0130	0.0153	0.0072	0.0130
Std. Deviations	0.0941	0.2226	0.2170	0.1238	0.4054	0.3937

According to these results highest opportunity of profitability in pair trading strategy is to be observed in the textile sector of PSX and lowest in the chemical sector. However, the average values under different parametrizations of standard deviations 1.5, 2 and 2,5 of all the three sectors are found to be positive. Conforming the profitability of pair trading strategy in PSX.

## *Quantitative Analysis*

To test the significance of portability i.e. to unveil the secret of profitability in pair trading this study uses t statistic. In the same way to observe the risk adjusted performance of trading portfolio capital asset pricing model is used. In CAPM, Jensen's alpha is more suitable measure to risk adjusted performance, so this study is also following this measure. The results of pair trading portfolios in general and risk adjusted performance in particular of all the three sectors; banking, chemical and textile under different parameterization are discussed in Table 4, 5 and 6. Further 4 broader categories of portfolios consisting of 5, 10, 15 and 20 pairs stocks are presented in these tables to check which broader category yield the highest level of profitability for investors under different parameterization.

In banking sector analysis, the results of pair trading strategies are found to positive and significant. Further, all the results under different parametrizations (1.5-SD, 2-SD & 2.5-SD) are also significant and positive. A statistically significant and positive results indicate that pair trading strategy is profitable at PSX. These results are also supportive and validating the profitability of pair trading strategy at PSX. Under different parameterization, that is trigger value of 2.5 and top-5 pairs portfolio witnessed with the highest average excess returns of 0.0839. Market neutrality is also proven at PSX. Further, as shown from these results at PSX, that pair trading strategy is different from other strategies, so it would be also beneficial for asset allocation fund managers as well in addition to other fund managers. A statistically significant and positive results indicate that pair trading strategy is profitable.

For risk adjusted performance Jensen's alpha of all pairs of 5, 10, 15 and 20 by using parameterizations (1.5-SD, 2-SD & 2.5-SD) are also significant and positive. These results of pair trading strategies are also validating the profitability and are same with the results of other studies like (Lei & Xu, 2015), Namwong, Yamaka, & Tansuchat (2019) and Smith and Xu (2017) etc. Therefore, the alternate hypothesis for profitability and risk adjusted returns are proved at PSX. This shows that PSX is also rewarding profitability, that is, by using pair trading strategy, investors of PSX can get positive returns.

**Table-4**

Sector: Banking	Top-20-Pairs			Top-15-Pairs		
Formation Period as Parameter A	1-Year (daily data of 1-year for each parameter B)					
Trigger as Parameter B	1.5	2	2.5	1.5	2	2.5
Port. Returns	0.0292	0.0451	0.0606	0.0400	0.0565	0.0673
Std. Deviations (Port. Returns)	0.0244	0.0397	0.0967	0.0356	0.0474	0.1200
T	10.6200	11.3167	6.3719	10.6650	8.5552	5.9233
P Values	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jensen-Alpha	0.0319	0.0426	0.0594	0.0368	0.0511	0.0650
S.E.	0.0119	0.0122	0.0165	0.0140	0.0122	0.0272
T	2.6807	3.4918	3.6000	2.6286	4.1885	2.3897
Betas	0.1739	0.9001	0.1768	0.3645	1.2468	0.2287
S.E.	0.2397	0.3361	0.8798	0.3145	0.4396	1.1010
T	0.7255	2.6781	0.2010	1.1590	2.8362	0.2077
Sector: Banking	Top-10-Pairs			Top-5-Pairs		
Formation Period as Parameter A	1-Year (daily data of 1-year for each parameter B)					
Trigger as Parameter B	1.5	2	2.5	1.5	2	2.5
Port. Returns	0.0349	0.0478	0.0578	0.0458	0.0646	0.0839
Std. Deviations (Port. Returns)	0.0443	0.0620	0.1840	0.0664	0.1214	0.3571
T	7.8767	7.1241	3.1985	6.4526	5.4491	2.3437
P Values	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jensen-Alpha	0.0410	0.0537	0.0646	0.0477	0.0874	0.0828
S.E.	0.0135	0.0169	0.0353	0.0207	0.0239	0.0484
T	3.0370	3.1775	1.8300	2.3043	3.6569	1.7107
Betas	0.6339	1.4121	0.0245	0.9225	2.2680	0.5701
S.E.	0.3998	0.5846	1.6112	0.6204	1.0716	3.1781
T	1.5855	2.4155	0.0152	1.4869	2.1165	0.1794

In Chemical sector analysis, the results of pair trading strategies are also found to positive and significant. Further, all the results under different parametrizations (1.5-SD, 2-SD & 2.5-SD) are also significant and positive. A statistically significant and positive results indicate that pair trading strategy is profitable at PSX. These results are also supportive and validating the profitability of pair trading strategy at PSX for chemical sector. Under different parameterization, that is trigger value of 2 and top-

10 pairs portfolio witnessed with the highest average excess returns of 0.0646. For risk adjusted performance Jensen's alpha of all pairs of 5, 10, 15 and 20 by using parameterizations (1.5-SD, 2-SD & 2.5-SD) are also significant and positive. These results of pair trading strategies are also validating the profitability and are same with the results of other studies like (Lei & Xu, 2015), Namwong, Yamaka, & Tansuchat (2019) and Smith and Xu (2017) etc. Therefore, the alternate hypothesis for profitability and risk adjusted returns are proved for chemical sector at PSX.

**Table-5**

Sector: Chemical	Top-20-Pairs			Top-15-Pairs		
Formation Period as Parameter A	1-Year (daily data of 1-year for each parameter B)					
Trigger as Parameter B	1.5	2	2.5	1.5	2	2.5
Port. Returns	0.0299	0.0482	0.0515	0.0332	0.0546	0.0464
Std. Deviations (Port. Returns)	0.0401	0.0955	0.1011	0.0443	0.1320	0.1327
T	7.6057	4.6077	4.1430	7.3607	4.3187	3.5295
P Values	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jensen-Alpha	0.0242	0.0398	0.0452	0.0276	0.0447	0.0375
S.E.	0.0082	0.0141	0.0213	0.0124	0.0216	0.0256
T	2.9512	2.8227	2.1221	2.2258	2.0694	1.4648
Betas	0.3815	1.2543	0.3794	0.3527	1.8050	0.9938
S.E.	0.3229	0.9101	0.9227	0.3680	1.1469	1.1681
T	1.1815	1.3782	0.4112	0.9584	1.5738	0.8508
Sector: Chemical	Top-10-Pairs			Top-5-Pairs		
Formation Period as Parameter A	1-Year (daily data of 1-year for each parameter B)					
Trigger as Parameter B	1.5	2	2.5	1.5	2	2.5
Port. Returns	0.0222	0.0646	0.0538	0.0012	0.0188	0.0020
Std. Deviations (Port. Returns)	0.0337	0.1892	0.1984	0.0127	0.0533	0.0117
T	6.2149	3.3523	2.7753	2.5392	2.9385	1.4391
P Values	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jensen-Alpha	0.0152	0.0512	0.0480	0.0015	0.0033	0.0004
S.E.	0.0050	0.0269	0.0373	0.0103	0.0079	0.0055
T	3.0400	1.9033	1.2869	0.1456	0.4177	0.0727
Betas	0.1143	2.3757	1.4260	0.1239	1.3245	0.0721
S.E.	0.3247	1.6530	1.7547	0.1321	0.4639	0.1340
T	0.3520	1.4372	0.8127	0.9379	2.8551	0.5381

**Table-6**

Sector: Textile	Top-20-Pairs			Top-15-Pairs		
Formation Period as Parameter A	1-Year (daily data of 1-year for each parameter B)					
Trigger as Parameter B	1.5	2	2.5	1.5	2	2.5
Port. Returns	0.0427	0.0844	0.0773	0.0419	0.0692	0.0574
Std. Deviations (Port. Returns)	0.0521	0.2517	0.2456	0.0676	0.1392	0.1381
T	7.0257	3.1941	3.1532	5.6793	4.4427	3.7790
P Values	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jensen-Alpha	0.0438	0.0812	0.0753	0.0341	0.0579	0.0558
S.E.	0.0085	0.0416	0.0379	0.0196	0.0260	0.0194
T	5.1529	1.9519	1.9868	1.7398	2.2269	2.8763
Betas	0.2440	0.8454	0.8843	0.1133	0.8787	0.7410
S.E.	0.4943	2.2895	2.1519	0.5864	1.2488	1.2773
T	0.4936	0.3693	0.4109	0.1932	0.7036	0.5801
Sector: Textile	Top-10-Pairs			Top-5-Pairs		
Formation Period as Parameter A	1-Year (daily data of 1-year for each parameter B)					
Trigger as Parameter B	1.5	2	2.5	1.5	2	2.5
Port. Returns	0.0578	0.0927	0.0869	0.0515	0.1134	0.0996
Std. Deviations (Port. Returns)	0.0886	0.2156	0.2138	0.1166	0.3992	0.3869
T	5.6550	3.9987	3.6666	4.2442	2.7647	2.4688
P Values	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jensen-Alpha	0.0518	0.0911	0.0812	0.0540	0.1148	0.0970
S.E.	0.0216	0.0312	0.0342	0.0229	0.0540	0.0516
T	2.3981	2.9199	2.3743	2.3581	2.1259	1.8798
Betas	0.0872	0.7704	1.0555	0.4397	1.0629	0.2169
S.E.	0.8206	1.8890	1.9219	1.0603	3.4965	3.4499
T	0.1063	0.4078	0.5492	0.4147	0.3040	0.0629

In Textile sector analysis, the results of pair trading strategies are also found to positive and significant. Further, all the results under different parametrizations (1.5-SD, 2-SD & 2.5-SD) are also significant and positive. A statistically significant and positive results indicate that pair trading strategy is profitable at PSX. These results are also supportive and validating the profitability of pair trading strategy at PSX for chemical sector. Under different parameterization, that is trigger value of 2.5 and top-5 pairs portfolio

witnessed with the highest average excess returns of 0.0996 and trigger value of 2.5 and top-10 pairs portfolio witnessed with the highest average excess returns of 0.0869.

For risk adjusted performance Jensen's alpha of all pairs of 5, 10, 15 and 20 by using parameterizations (1.5-SD, 2-SD & 2.5-SD) are also significant and positive. These results of pair trading strategies are also validating the profitability and are same with the results of other studies like (Lei & Xu, 2015), Namwong, Yamaka, & Tansuchat (2019) and Smith and Xu (2017) etc. Therefore, the alternate hypothesis for profitability and risk adjusted returns are proved for textile sector at PSX. In summary, under different parameterization, positive significant results are witnessed by all the three sectors (banking, chemical and textile) at PSX. Where, highest returns were in textile sectors. The results also validate the market neutrality, mean revision and challenge to EMH. However, the results of systematic risk under different parameterizations are some significant and some are insignificant.

## CONCLUSION

One of the profitable strategies in construction of portfolio is pair trading strategy, which is tested in three different sectors (chemical, textile and banking) of PSX. To capture the profitability through pair trading, co-integration approach is used in this study. Two stages are used in pair trading, one is formation period while other is trading period. The formation of pairs take place by using the daily data of each firm of these three sectors from year 2011 to year 2019. Different parameterizations are used for trading system algorithm like 1.5-SD, 2-SD & 2.5-SD. Positive and significant returns are generated from co-integration approach. Further, positive risk adjusted returns are also be observed in all the three sectors. A statistically significant and positive results indicate that pair trading strategy is profitable at PSX. The results also validate the market neutrality, mean revision theories and against the EMH. Further, as shown from these results at PSX, that pair trading strategy is different from other strategies, so it would be also beneficial for asset allocation fund managers as well for other fund managers. As a policy implication of this study, portfolio fund managers and different investors can reap the probability of this strategy in all the three sectors and specially in textile sector at PSX. This study has many limitations like only one methodology of co-integration approach, only three sectors with 16 firms each etc. are used. Therefore, for future research, different mythologies like clustering, distance approach and copulas may be used.

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