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A Simple Pairs Trading Strategy for ISE30

Pairs trading is a popular method of speculation in asset markets and relies on the assumption that there exist temporary deviations in co-movements of asset pairs prices. The difference between the prices of these assets is called *spread* and its calculation lies at the heart of the analysis.

When the two related stocks move away from their suggested equilibrium level, the *statistical arbitrage theory* suggests that a profitable investment strategy might occur by taking a *long position* in the relatively undervalued stock and a *short position* in the relatively overvalued stock. Profit potential arises from the assumption that the spread will revert back since, the deviation in spread is presumably a mispricing and is expected to correct itself overtime.

The main purpose of this study is NOT to offer buying or selling strategies/recommendations of any kind. Rather, the study aims to provide a feasible analytical framework that can be used as an effective tool in forming trading strategies for the Turkish stock market. Therefore, only the model itself should be of interest to anyone who will show any interest in the study by any chance.

We limit the scope of this study to securities listed in ISE30 for liquidity concerns. The general outline of pairs trading begins with finding stocks that move together. Although we will follow a purely empirical approach to identify the pairs, we strongly suggest the use of methodologies that take into account valuation concepts as well as traders' valuable insights (those which can be validated by data).

Co-movement of two time series can be analyzed through several methods. The simplest approach is correlation. A more elaborate way to examine this relationship is to determine the cointegration dynamics between the two series. For the correlation part, we prefer to calculate the moving correlation with a window of 250 trading days (roughly a year) and extract the 20th and 80th percentile values as descriptive measures in order to avoid extreme values.

We employ Johansen procedure for the formal testing of cointegration relationship. However, we use nonstationary regression methods to estimate the parameters of cointegration equation and *Fully Modified OLS (FM-OLS)* is our preferred method. Our sample covers January 2, 2008 and April 29, 2011 period, where we keep the last six months of the data for testing purposes and delete the missing values on a case-wise basis.

For comparison purposes, we also employ the distance method that measures the spread between the normalized prices of stocks. In short, we make use of following equations:

$$D_t = \frac{P_t^1 - E(P_t^1)}{\sigma_{P_t^1}} - \frac{P_t^2 - E(P_t^2)}{\sigma_{P_t^2}}$$

$$\log(P_t^1) = \gamma_0 + \gamma_1 * \log(P_t^2) + \varepsilon_t$$

Our pair selection criteria are primarily based on trace test results of the Johansen procedure. If the probability of the test statistic is smaller than %5, we fail to reject that the variables are cointegrated and pick the pair for further analysis. We have two additional criteria for the selection process: **i)** R-squared should be greater than 85%, and **ii)** number of observations should be greater than half of the sample.

Results of the pair selection procedure (*28 pairs out of all possible 435 pairs*) are shown in the Appendix (**Table-1**).

Having completed the selection procedure, we can move on to generate statistical trading strategies. Our analysis is mainly based on the *stochastic spread method* which effectively models the mean reversion behavior of the spread. The details of the model can be found in: Elliott, R., van der Hoek, J. and Malcolm, W. (2005). "Pairs Trading", *Quantitative Finance*, vol. 5(3), 271-276.

We slightly modified the stochastic spread method so as to allow for a time varying mean as the long term value of the level differences need not be a constant: Our version of the model is as follows:

$$\begin{aligned} S_t &= \beta_{0t} + (1-\theta) * S_{t-1} + \varepsilon_t^S \\ \beta_{0t} &= \beta_{0t-1} + \Delta\beta_{0t-1} \\ \Delta\beta_{0t} &= \Delta\beta_{0t-1} + \varepsilon_t^{\Delta\beta} \\ 0 &< \theta < 1 \end{aligned}$$

Please note that the above model defines the movement of time varying parameter as a smooth stochastic trend instead of a random walk, since the mean is considered as the long term equilibrium value. This specification is superior to moving average method of any kind, since it does not introduce a phase shift. The spread here is calculated as the logarithmic difference of price levels, which also rules out undesirable erratic fluctuations in the mean.

The mean reversion parameter, θ, can also be allowed to vary over time. The model, however, then becomes excessively flexible and leaves no room for measurement error. Since theory assumes that the process is mean reverting, our aim is to find a relatively stable mean level that does not change drastically in the short term.

The model is put into state space form and estimated via Kalman filter. Smoothed state variables are used for the calculation of mean ($\boldsymbol{\mu_t}$) and its standard deviation ($\boldsymbol{\sigma_t}$).

As for developing a plausible trading rule, we need to define a certain threshold level, above/below which one can extract what we can label a signal for a pairs trading opportunity. Rather than providing it exogenously, we prefer to endogenize the calculation of the threshold and search for the optimum level that has provided the maximum return over the past three years (prior to our testing period). Below is the outline of our model:

$$Maximize: \; R = \sum_{t=1}^{T}(\pi_t - m_t) - 2*c*N$$

$$\pi_t = \begin{cases} {}^{ask}\Delta p_t^2 - {}^{bid}\Delta p_t^1, & if \; LS_t = 1 \\ {}^{ask}\Delta p_t^1 - {}^{bid}\Delta p_t^2, & if \; LS_t = -1 \\ 0, & elsewhere \end{cases}$$

$$m_t = \begin{cases} {}^{ask}p_{t-1}^2 - {}^{bid}p_{t-1}^2, & if \; LS_{t-1} = 1 \; and \; \Delta LS_t = -1 \\ {}^{ask}p_t^1 - {}^{bid}p_t^1, & if \; LS_t = 1 \; and \; \Delta LS_t = 1 \\ {}^{ask}p_{t-1}^1 - {}^{bid}p_{t-1}^1, & if \; LS_{t-1} = -1 \; and \; \Delta LS_t = 1 \\ {}^{ask}p_t^2 - {}^{bid}p_t^2, & if \; LS_t = -1 \; and \; \Delta LS_t = -1 \\ 0, & elsewhere \end{cases}$$

$$LS_t = \begin{cases} 1, & if \; S_{t-1} > \mu_{t-1} + \gamma * E(\sigma_t^{\mu}) \\ -1, & if \; S_{t-1} < \mu_{t-1} - \gamma * E(\sigma_t^{\mu}) \\ 0, & elsewhere \end{cases}$$

$$1.96 \le \gamma \le \max(\mu_t / E(\sigma_t^{\mu}))$$

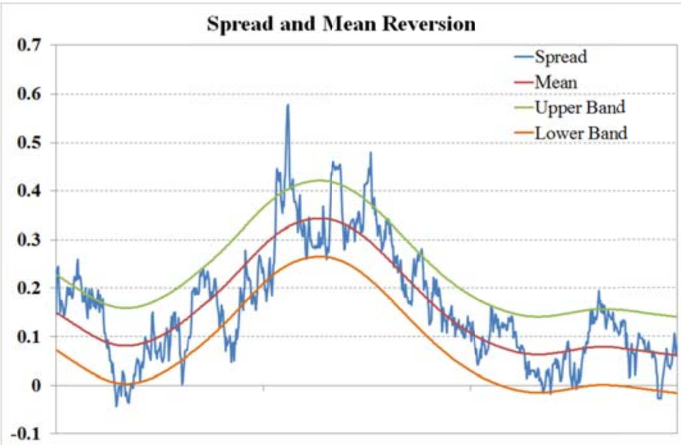
Here, $\boldsymbol{p}$ indicates daily log prices of stocks and $\boldsymbol{\pi}$ is the related log returns. $\boldsymbol{m}$ captures the accompanying cost of bid-ask spread in each transaction. $\boldsymbol{N}$ represents the total number of opened and closed trades, whereas $\boldsymbol{c}$ is the associated cost with each transaction and is equal to 0.0015. $\boldsymbol{LS}$ denotes long and short positions. The spread ($\boldsymbol{S}$) is calculated as the difference between normalized prices or the signal estimates of the state space model depending on the chosen method (*i.e. stochastic spread method or distance method*).

The decision variable is the coefficient of standard deviation, γ, which defines the range out of which trading occurs. We are interested in the optimum threshold level that maximizes the total return over the sample period. In order to avoid *false/superfluous* signals, we impose a lower bound on the γ value.

We prefer *simulated annealing method* for the optimization in order to avoid being trapped in local maxima as the objective function is quite non-smooth. Results are presented in the Appendix (**Table-2**)

First column of the table displays the final value of the smoothed mean estimate from the Kalman filter. Second and third columns refer to optimization results of threshold coefficient (γ) of each pair calculated for **(1)** *modified stochastic spread method* and **(2)** *the distance method*. Fourth and fifth columns present associated returns for the three-year period.

Some of the estimated threshold values equal to the lower bound implying that the actual optimum value lies somewhere below the lower bound. We prefer not to loosen the constraint and treat any value that falls inside the 95% confidence interval as pure noise. The chart below depicts the outcome of this analysis on the first pair (AKBNK-GARAN), which is chosen only for demonstration purposes:



According to a simple buy-and-hold strategy, the ISE30 would have yielded a return of 38.2% over the three year estimation period. Although the calculated returns of this trading strategy might whet an investor's appetite, one should keep in mind that these results are discovered after the fact and thus do not guarantee any future gains. An out-of-sample exercise is necessary to measure the performance of any trading strategy. Here, we tested our methodology over a six month period following the estimation period.

Once we identify the threshold level, we keep it as is along the testing period and calculate the total return for each pair. We run both methods over the next six months with a rolling window of three years and generated one-step ahead trading signals. Results are summarized in the Appendix (**Table-3**).

First column of the Table-3 is same as the Table-2 for comparison purposes. Second column of Table-3 presents the final value (*at the end of six months*) of the smoothed mean estimate from the Kalman filter. Third and fourth columns refer to associated returns of each pair for the next six months calculated for **(1)** *modified stochastic spread method* and **(2)** *the distance method*.

Zero returns indicate that the spread has fluctuated within the confidence interval during this period and therefore no trading has occurred. An equally weighted portfolio from these traded pairs would have produced a return of 3.0% and -9.2%, respectively. Given the fact that the return of ISE30 during this period was -6.5%, it could be said pairs trading generated discernible excess return (*with the first trading strategy at least*).

Although we have a disclaimer at the bottom of the paper, we would like to remind the reader once again that the results of the study should not be interpreted as a trading advice. The outcome of this study simply provides evidence for the existence of a window of opportunity for pairs trading. An applicable version of the model, however, requires a more thorough analysis for both selection and rule generation steps.

APPENDIX

Table 1. Results of Pair Selection Procedure

Pairs	Cor %20	Cor %80	Trace Test	Pair Coef	Const Coef	R^2
AKBNK-GARAN	0.896	0.973	0.0165	0.766	0.510	95.3%
AKBNK-ISCTR	0.897	0.965	0.0094	1.036	0.372	94.0%
AKBNK-KCHOL	0.860	0.937	0.0189	0.834	0.621	88.5%
AKBNK-SAHOL	0.882	0.947	0.0037	0.969	0.119	89.5%
AKBNK-VAKBN	0.888	0.964	0.0148	0.700	0.963	87.9%
AKBNK-YKBNK	0.884	0.945	0.0109	0.997	0.591	91.4%
ARCLK-HALKB	0.906	0.967	0.0001	1.384	-1.461	86.6%
ARCLK-KCHOL	0.740	0.964	0.0183	1.501	-0.556	88.9%
ARCLK-SAHOL	0.705	0.939	0.0025	1.742	-1.458	89.6%
ARCLK-SISE	0.782	0.962	0.0240	1.831	0.538	92.5%
ARCLK-SNGYO	0.887	0.966	0.0270	1.020	1.071	90.2%
ARCLK-VAKBN	0.597	0.961	0.0010	1.273	0.045	90.5%
ASYAB-SNGYO	0.815	0.972	0.0058	0.782	0.814	91.4%
ENKAI-KRDMD	0.650	0.952	0.0061	0.989	2.171	88.9%
GARAN-HALKB	0.925	0.982	0.0045	1.029	-0.564	95.7%
GARAN-KCHOL	0.893	0.957	0.0222	1.084	0.150	92.0%
GARAN-SAHOL	0.867	0.962	0.0092	1.251	-0.490	91.4%
GARAN-VAKBN	0.830	0.973	0.0209	0.919	0.586	93.2%
HALKB-ISCTR	0.831	0.966	0.0311	1.265	0.433	94.1%
HALKB-KCHOL	0.768	0.947	0.0350	1.040	0.710	93.0%
HALKB-TUPRS	0.615	0.936	0.0304	1.169	-1.535	88.3%
IHLAS-KRDMD	0.632	0.947	0.0212	1.496	0.201	87.6%
ISCTR-KCHOL	0.822	0.968	0.0078	0.813	0.231	95.6%
ISCTR-YKBNK	0.863	0.977	0.0005	0.965	0.209	97.3%
KCHOL-YKBNK	0.881	0.968	0.0087	1.159	0.003	96.2%
KOZAA-SNGYO	0.877	0.956	0.0005	0.953	0.863	91.2%
SNGYO-TEBNK	0.799	0.952	0.0065	1.100	-0.249	91.1%
TEBNK-VAKBN	0.790	0.977	0.0254	1.046	-0.601	92.3%

Table 2. Optimization Results of Threshold Analysis

Pairs	Mean (final)	γ(1)	γ(2)	3-Year Return(1)	3-Year Return(2)
AKBNK-GARAN	0.062	2.223	1.982	91.7%	69.1%
AKBNK-ISCTR	0.356	2.053	2.055	98.6%	37.1%
AKBNK-KCHOL	0.288	1.960	2.034	192.6%	101.9%
AKBNK-SAHOL	0.162	1.960	2.329	134.4%	54.2%
AKBNK-VAKBN	0.665	2.044	1.960	118.3%	54.1%
AKBNK-YKBNK	0.516	2.492	2.190	116.5%	83.5%
ARCLK-HALKB	-0.659	2.023	1.988	272.3%	110.4%
ARCLK-KCHOL	0.128	1.991	2.032	319.4%	94.1%
ARCLK-SAHOL	-0.032	1.978	1.978	512.6%	141.7%
ARCLK-SISE	1.016	1.960	1.996	219.6%	44.0%
ARCLK-SNGYO	1.375	2.243	2.012	230.3%	154.6%
ARCLK-VAKBN	0.514	2.012	2.389	289.9%	145.7%
ASYAB-SNGYO	0.601	2.222	2.765	252.1%	36.1%
ENKAI-KRDMD	2.196	1.999	2.133	125.3%	56.4%
GARAN-HALKB	-0.494	2.167	2.475	171.0%	48.1%
GARAN-KCHOL	0.313	2.148	2.564	102.5%	56.6%
GARAN-SAHOL	0.089	2.145	2.036	165.2%	39.2%
GARAN-VAKBN	0.619	2.415	2.010	92.8%	32.4%
HALKB-ISCTR	0.847	1.983	2.078	236.1%	66.3%
HALKB-KCHOL	0.788	3.203	2.080	160.4%	116.1%
HALKB-TUPRS	-0.881	2.086	2.554	262.1%	49.2%
IHLAS-KRDMD	0.200	3.262	1.997	166.2%	60.2%
ISCTR-KCHOL	-0.088	2.006	2.355	169.9%	31.9%
ISCTR-YKBNK	0.167	2.982	2.372	86.9%	49.8%
KCHOL-YKBNK	0.243	1.960	1.979	126.9%	54.8%
KOZAA-SNGYO	0.660	1.976	2.088	865.4%	446.5%
SNGYO-TEBNK	-0.046	2.012	2.169	523.1%	280.3%
TEBNK-VAKBN	-0.708	2.040	2.361	136.7%	65.3%

Table 3. Performance Analysis in the Testing Period

Pairs	Mean-old (final)	Mean-new (final)	6-Month Return(1)	6-Month Return(2)
AKBNK-GARAN	0.062	0.019	0.0%	2.8%
AKBNK-ISCTR	0.356	0.416	-2.0%	-1.2%
AKBNK-KCHOL	0.288	-0.026	-0.2%	-32.1%
AKBNK-SAHOL	0.162	0.045	33.2%	-17.2%
AKBNK-VAKBN	0.665	0.673	0.0%	16.3%
AKBNK-YKBNK	0.516	0.477	-3.7%	19.1%
ARCLK-HALKB	-0.659	-0.450	0.0%	-3.0%
ARCLK-KCHOL	0.128	0.030	-0.3%	-2.8%
ARCLK-SAHOL	-0.032	0.035	0.0%	-0.6%
ARCLK-SISE	1.016	0.778	1.1%	-18.7%
ARCLK-SNGYO	1.375	1.343	0.0%	-32.0%
ARCLK-VAKBN	0.514	0.761	0.0%	-10.6%
ASYAB-SNGYO	0.601	0.351	-4.5%	6.7%
ENKAI-KRDMD	2.196	1.910	-33.4%	-10.8%
GARAN-HALKB	-0.494	-0.530	2.2%	5.5%
GARAN-KCHOL	0.313	-0.031	26.6%	-18.8%
GARAN-SAHOL	0.089	0.128	-8.2%	-8.9%
GARAN-VAKBN	0.619	0.651	0.0%	4.3%
HALKB-ISCTR	0.847	0.910	0.0%	-5.9%
HALKB-KCHOL	0.788	0.657	0.0%	-21.6%
HALKB-TUPRS	-0.881	-1.279	-0.4%	-27.7%
IHLAS-KRDMD	0.200	0.885	0.0%	-32.1%
ISCTR-KCHOL	-0.088	-0.446	10.7%	-25.1%
ISCTR-YKBNK	0.167	0.077	28.4%	7.1%
KCHOL-YKBNK	0.243	0.526	19.0%	-14.9%
KOZAA-SNGYO	0.660	0.934	0.6%	6.7%
SNGYO-TEBNK	-0.046	-0.027	4.4%	-18.5%
TEBNK-VAKBN	-0.708	-0.656	4.8%	8.2%

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