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Copula-Based Pairs Trading in Local Markets

Background: Pairs Trading & Copulas

Pairs trading is a widely accepted quantitative trading strategy originated from Wall Street. The intrinsic idea of pairs trading is to identify a pair of stocks whose prices move together in their history. Subsequently, long/short positions are constructed when the stock prices are undervalued/overvalued relative to their counterparty. The profitability of this trading strategy depends on the assumption of mean-reverting property, which states that stock prices will eventually return to their equilibrium positions if they deviate from each other.

Distance method is the most commonly implemented pairs trading strategy by traders and hedge funds. However, this approach, which can be seen as a standard linear correlation analysis, is only able to fully describe the dependency structure between stocks under the assumption of multivariate normal returns. To overcome this limitation, we propose a new pairs trading strategy using copula modelling technique. Copula allows separate estimation of the marginal distributions of stock returns as well as their joint dependency structure. Thus, the proposed new strategy, which is based on the estimated optimal dependency structure and marginal distributions, can identify relative undervalued or overvalued positions with more accuracy and confidence. Hence, it is deemed to generate more trading opportunities and profits.

Figure 1
Distance Strategy: Plot of normalized prices and spread (Spread Structure Changed)
Pair: Brookdale Senior Living Inc. and Emeritus Corporation (BKD-ESC)
Formation Period: 02 January 2008 – 30 December 2008
Trading Period: 31 December 2008 – 01 July 2009

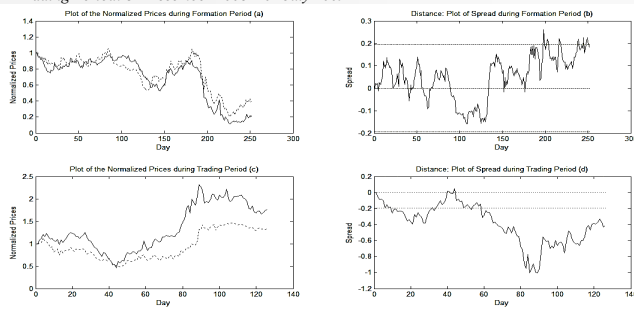
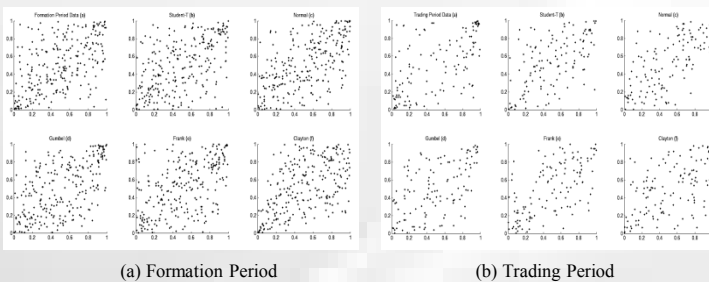


Figure 2
Comparison of dataset against copulas fitted (Dependency Structure Invariant)
Pair: Brookdale Senior Living Inc. and Emeritus Corporation (BKD-ESC)
Formation Period: 02 January 2008 – 30 December 2008
Trading Period: 31 December 2008 – 01 July 2009



Methodology: Copula-Based Pairs Trading Strategy

We define our mispricing Indexes as follows.

Definition If R_t^X and R_t^Y represent the random variables of daily returns of stock X and stock Y at day t, and the realizations of the returns on day t are r_t^X and r_t^Y , we define

$$MI_t^{X|Y} = P(R_t^X < r_t^X | R_t^Y = r_t^Y)$$

$$MI_t^{Y|X} = P(R_t^Y < r_t^Y | R_t^X = r_t^X)$$

The copula-based trading strategy is as follows.

Formation Period

During formation period, daily return series R_t^X and R_t^Y are calculated. Then, the best fitted marginal distributions of R_t^X and R_t^Y are estimated. After obtaining the estimated marginal distributions for R_t^X and R_t^Y , the optimal dependency structure is estimated by employing different categories of copulas (Gumbel, Frank, Clayton, Normal and Student-T) and the one with the highest likelihood value is chosen.

Trading Period

During trading period, daily returns of stock X and stock Y are calculated as well. Meanwhile, $MI_t^{X|Y}$ and $MI_t^{Y|X}$ are calculated using the estimated copula from formation period. Trading indicators are defined as $FlagX$ and $FlagY$ and are set to zero before the commencement of trading period. During the trading period itself, $(MI_t^{X|Y} - 0.5)$ and $(MI_t^{Y|X} - 0.5)$ are added to $FlagX$ and $FlagY$ respectively, on a daily basis. In addition, D is defined as the trigger point and S is defined as the stop-loss position. The following are the four possible cases for an open position (assuming that no trades are open):

- When $FlagX$ reaches D , we short-sell stock X and buy stock Y with equal amount.
- When $FlagX$ reaches $-D$, we short-sell stock Y and buy stock X with equal amount.
- When $FlagY$ reaches D , we short-sell stock Y and buy stock X with equal amount.
- When $FlagY$ reaches $-D$, we short-sell stock X and buy stock Y with equal amount.

If trades are opened based on $FlagX$, then the trades are closed if $FlagX$ returns to 0 or reaches the stop-loss positions S or $-S$. If trades are opened based on $FlagY$, then the trades are closed if $FlagY$ returns to 0 or reaches the stop-loss positions S or $-S$. After trades are closed, both $FlagX$ and $FlagY$ are reset to 0. At the end of trading period, all opening trades are closed regardless of the values of $FlagX$ and $FlagY$.

Empirical Results: Local Banks as an Illustration (2009-2013)

Figure 3
Daily stock prices of UOB, DBS and OCBC from 2009-2013.

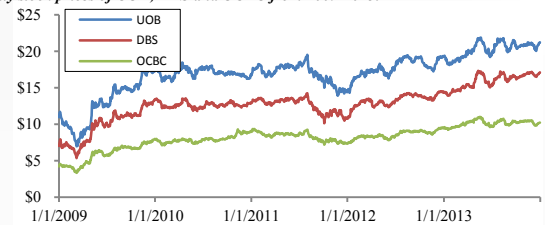


Table 1
Returns of top pair selected from local banking sector
5 recent years daily stock prices of DBS, UOB and OCBC are obtained from yahoo finance. They are ran six trading cycles, and performance of the top pair selected is shown below.

	Copula	Copula (one day waiting)	Distance	Distance (one day waiting)
Average excess returns	0.0052	0.0055	0.0000	0.0030
Median	0.0027	0.0034	0.0000	0.0000
Standard Deviation	0.0340	0.0333	0.0279	0.0285
Skewness	-0.0909	0.0276	0.2875	1.0130
Kurtosis	2.3678	3.5714	7.8635	7.9291
Minimum	-0.0724	-0.0820	-0.0717	-0.0686
Maximum	0.0653	0.0906	0.1008	0.1037
Average no. of trades per pair	6.6667	6.6667	1.6667	1.6667
Average time pairs are open in months	4.6111	4.5794	2.7302	2.6984

Conclusion & Future Research

Copula-based trading strategy is built on the optimal estimated dependency structure and marginal distributions, and thus can generate higher excess return than the conventional distance method. Our future research will focus on the pairs selection process as well as “multi-stock” pairs trading.

Main Reference

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- Xie, W., Liew, R., Q., Wu, Y., and Zou, X. (2014). Pairs Trading with Copulas. Working paper, Nanyang Technological University.

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