# *Efficiently Inefficient*

***How Smart Money Invests and Market Prices Are Determined***

## Solution to Exercises for
## *Understanding Hedge Funds and Other Smart Money*

1.1. **Selection vs. Timing.** Market timing is a trading strategy that tactically varies the overall exposure to a market, e.g. an equity market, bond market, commodity market, credit market, or currency. For instance, an equity market timing varies the market beta over time. A security selection strategy chooses which securities are preferred to others, going long (or overweight) the "good" securities and short (or underweight) the "bad" ones. Hence, a key difference is that a selection strategy can be implemented with constant overall market exposure while a timing strategy is all about varying the market exposure. Similarities include that both strategies are active and seek to beat a passive market exposure, thus both strategies rely on an assumption of less than full market efficiency.

1.2. **Biases.** This analysis is flawed since because, 5 years ago, you did not know which stocks would be the largest in their industry today. Further, the analysis is not just flawed by a "random" look-ahead bias, it is biased in a way that could well drive the result: if a stock has become the largest in its industry, it is likely because it has done well over the past 5 years, but, again, you could not have known this back then. A correct way to test the idea is to look at the stocks that were industry leaders some time in the past based on data available back then, and see how such stocks perform going forward. In conclusion, the hedge fund should not pursue this strategy based on a flawed analysis, but could analyze the strategy more carefully (and over a longer time period).

1.3. **Hedge funds vs. mutual funds.**

a. The hedge fund's volatility is $4\times3.5\% = 14\%$.

b. The hedge fund's beta is 0.

c. The hedge fund's alpha before fees is its expected excess return minus its beta times the equity risk premium, i.e., $4\times2.20\% - 0 = 8.80\%$.

d. The equivalent portfolio invests \$40 in the passive fund, \$10 in the hedge fund, and \$50 in cash. This portfolio has the same market exposure, same alpha before fees, same expected return before fees, same volatility, and same exposure to $\varepsilon_t$ . The fair management fee for the hedge fund in the sense that it would make the investor indifferent between the two allocations is 4.40% since this equates the total fees:

   \$40×1.20%+\$60×0% = \$40×0.10%+\$10×4.40%+\$60×0%

e. The hedge fund's expected return in excess of $r^f$ before fees is 8.80% so the expected excess return net of a management fee of 2% is 6.80%. Therefore, a 35.3% performance fee makes the expected fee the same as above (ignoring high water marks and the fact that returns can be negative):

   4.40% = 2% + 0.353 × 6.80%

f. Based on the example in this exercise, the hedge fund would in fact be cheap relative to the mutual fund if it were to charge 2-and-20 fees. Fees should be judged relative to the alpha that the investment manager delivers.

   Hedge fund fees are high, and perhaps too high in some cases, but it is important to make an appropriate comparison when looking at funds with different market exposure, volatility, and other characteristics. As this example shows, some mutual funds may in fact be even more expensive per unit of alpha that they deliver. Another implication is that, if two hedge funds run the same strategy but at different levels of leverage, then the high-leverage fund should charge a larger fee since it should have a correspondingly larger alpha.

1.4. **Styles and Strategies**

a. Here are some suggested answers, although there is not a single correct answer here:

| Long-short equity | Short biased | Quant equity | Global macro | Man. futures | Fixed income arb | Convert bond arb | Event driven arb |
|---|---|---|---|---|---|---|---|
| Name the securities most commonly used | | | | | | | |
| stocks | stocks | stocks | futures, currencies, bonds futures, commodity futures, swaps, options, credit derivatives | equity futures, currency forwards, bond futures, commodity futures | cash bonds, bond futures, swaps, fixed income derivatives | convertible bonds, short stocks, possibly bond futures, CDS | stocks, corporate bonds, options |
| Invests in liquid securities (1=highly illiquid, 5=highly liquid) | | | | | | | |
| 4 | 3 | 4 | 5 | 5 | 3 | 1 | 3 |
| Has a large turnover (1=very low turnover, 5=high turnover) | | | | | | | |
| 3 | 3 | 4 | 3 | 4 | 4 | 2 | 3 |
| Uses a lot of leverage (1=unlevered, 5=super high leverage) | | | | | | | |
| 3 | 2 | 3 | 3 | 3 | 5 | 4 | 2 |
| Discretionary/heuristic or quantitative/systematic (1=gut driven, 5=model driven) | | | | | | | |
| 2 | 2 | 5 | 2 | 5 | 4 | 4 | 3 |
| Left tail (1=often positive return, but sometimes blows up, 5=positive skewness) | | | | | | | |
| 3 | 5 | 3 | 3 | 4 | 1 | 2 | 2 |
| Name one or more hedge funds in this style | | | | | | | |
| | | | | | | | |

b., c., and d.: See the book.

# *Efficiently Inefficient*

***How Smart Money Invests and Market Prices Are Determined***

## Solution to Exercises for
## *Evaluating Trading Strategies: Performance Measures*

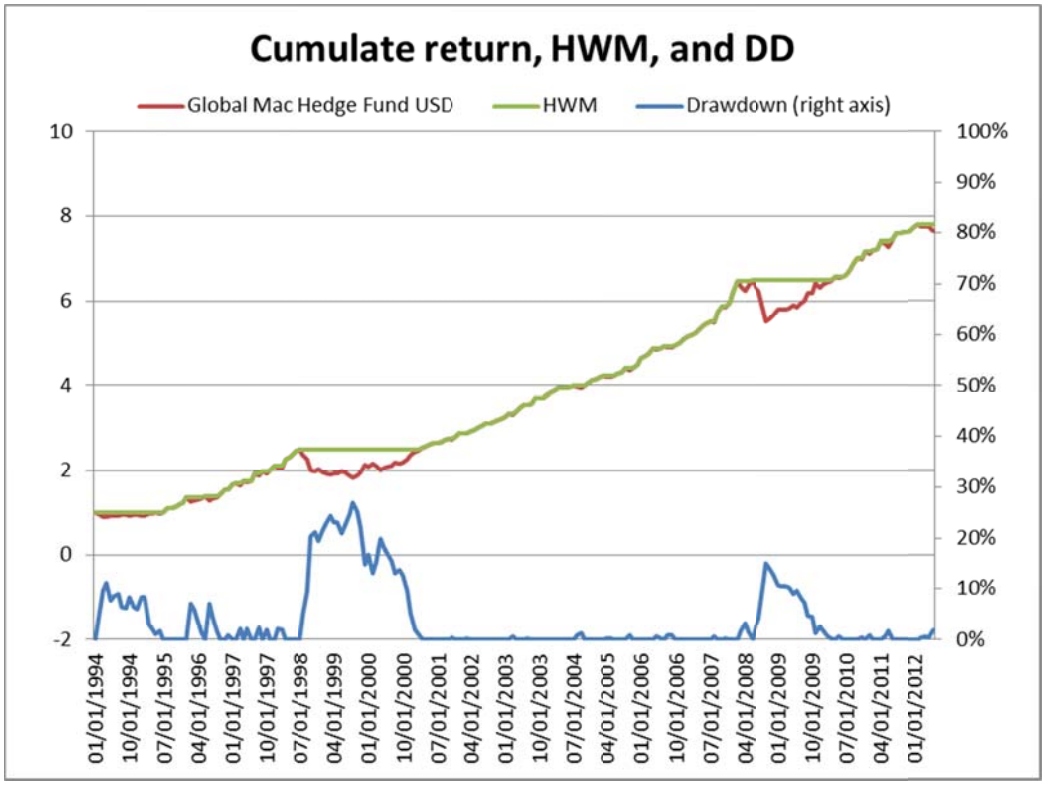
### 1.1. Performance measures.

| | Ln/Sh Eq Hedge Fund USD | Eq Mkt Ntr Hedge Fund USD | Ded Sh Bs Hedge Fund USD | Global Mac Hedge Fund USD | Mngd Fut Hedge Fund USD | Emg Mkts Hedge Fund USD | Evnt Drvn Hedge Fund USD | Cnvrt Arb Hedge Fund USD | Fx Inc Arb Hedge Fund USD | DJCS Hedge Fund USD |
|---|---|---|---|---|---|---|---|---|---|---|
| **Ann. arith. ave. ret** | 9.04% | 5.29% | -2.66% | 11.51% | 6.13% | 7.99% | 8.83% | 7.35% | 5.24% | 8.41% |
| **Ann. geo. ave. ret** | 8.89% | 4.68% | -4.01% | 11.63% | 5.59% | 7.08% | 8.98% | 7.34% | 5.19% | 8.44% |
| **Ann. volatility** | 9.90% | 10.22% | 16.97% | 9.64% | 11.69% | 14.89% | 6.29% | 6.90% | 5.73% | 7.50% |
| **Ann. Sharpe ratio** | 0.61 | 0.22 | -0.34 | 0.88 | 0.26 | 0.33 | 0.92 | 0.62 | 0.38 | 0.72 |
| **Market beta** | 0.46 | 0.19 | -0.86 | 0.15 | -0.07 | 0.54 | 0.26 | 0.17 | 0.13 | 0.29 |
| **Ann. alpha to MKT** | 3.19% | 1.08% | -0.47% | 7.54% | 3.52% | 1.62% | 4.18% | 3.25% | 1.41% | 3.59% |
| **Ann. IR** | 0.49 | 0.11 | -0.05 | 0.81 | 0.30 | 0.14 | 0.91 | 0.52 | 0.27 | 0.62 |
| **Max drawdown** | 22.14% | 45.13% | 64.24% | 27.00% | 17.88% | 45.33% | 19.30% | 33.00% | 29.10% | 19.82% |
| **Skewness** | -0.07 | -11.99 | 0.65 | -0.10 | 0.02 | -0.81 | -2.24 | -2.57 | -4.23 | -0.27 |
| **Excess kurtosis** | 3.20 | 165.33 | 1.31 | 3.90 | -0.03 | 5.14 | 11.38 | 15.82 | 29.38 | 2.44 |

Rather than just looking at such summary statistics, it is important to actually look at the data, e.g., looking at the cumulative returns, seeing if there are strange data points, risks that stand out, potential errors in the data, etc.

For instance, looking at the time series of equity market neutral, it is clear that something strange is going on. This is because a large fraction of the index was feeder funds that invested in the Ponzi scheme of Bernard Madoff. This issue means that the returns before 2008 are based partly on numbers made up by Madoff and the large loss in 2008 is due to the discovery of the fraud.

1.2. **Cumulative return and drawdown.**




1.3. **Factor models.** For Equity Long/Short:

**Univariate factor loadings**

| | Mkt-RF | Const |
|---|---|---|
| Coefficient | 0.46 | 0.27% |
| Standard err. | 0.03 | 0.13% |
| t-statistic | 17.13 | 2.10 |

**Multivariate factor loadings**

| | UMD | HML | SMB | Mkt-RF | Const |
|---|---|---|---|---|---|
| Coefficient | 0.17 | -0.08 | 0.18 | 0.47 | 0.16% |
| Standard err. | 0.02 | 0.03 | 0.03 | 0.02 | 0.10% |
| t-statistic | 9.06 | -2.70 | 6.15 | 21.15 | 1.69 |

a. The long/short equity managers appear to be more long than short (because of the positive market beta), prefer small stocks (because of the positive loading on SMB), stocks with upward momentum (because of the positive loading on UMD), and, perhaps surprisingly, stocks that are expensive in terms of the book-to-market ratio (because of the negative loading on HML).

b. Univariate vs. multivariate alpha:

| Comparison of alphas | | |
|---|---|---|
| | Monthly | Annual |
| Univariate alpha | 0.27% | 3.19% |
| Multivariate alpha | 0.16% | 1.93% |

We see that the multivariate alpha is lower since part of the performance is explained by the factor exposures. Given that there exists no free way of getting access to momentum, size, and other factors, the multivariate alpha should be interpreted carefully in light of the benefits and alternative costs of these factors. Indeed, investors may view the funds' value added both as providing such factor exposures and as adding alpha beyond that. For an investor who can otherwise only access the overall equity market, the univariate alpha may be a better way to describe the value of adding equity long/short to the portfolio.

1.4. **Illiquidity and stale prices.** For Convertible Bond Arbitrage, compare:

a., b., and c. The estimated total beta and annualized alpha based on each of three methods are:

| | Beta (sum) | Annualized alpha |
|---|---|---|
| **Standard 1M** | 0.17 | 3.25% |
| **Standard 3M** | 0.30 | 2.50% |
| **With two market lags** | 0.32 | 2.39% |

We see that the standard monthly regression underestimates the market beta and, therefore, overestimates the alpha. The two ways of handling illiquidity and stale prices (or performance smoothing), namely using quarterly data or including lagged market returns in the regression, yield almost the same results in this case.

# *Efficiently Inefficient*

***How Smart Money Invests and Market Prices Are Determined***

## Solution to Exercises for *Finding and Backtesting Strategies: Profiting in Efficiently Inefficient Markets*

3.1. **Information collection.** Look at the book and make your own examples – there is endless number of examples out there.

3.2. **Adverse selection and IPOs.**

- If the IPO price is fixed, getting a share in an oversubscribed IPO is attractive because the high interest in the stock can drive up the price in the secondary market. Indeed, the interested investors who asked for shares in the IPO, but did not get any (or not as many as they wanted) may buy some in the secondary market and, therefore, the secondary market price may trade above the IPO price. This effect may be mitigated if the high pre-IPO interest leads to a higher IPO price, but the return of oversubscribed IPOs may still be high on average. An undersubscribed IPO, on the other hand, may reflect that the IPO price is too high to generate sufficient demand and, as a result, the stock price may fall in the secondary market.
- You will get your full allocation of IPO shares if it is undersubscribed, but, if the offering is oversubscribed, you risk getting fewer shares. Given that you are most likely to get shares in the case with lower expected return (the undersubscribed IPOs), your expected return is below that of a random IPO.
- No, because of the problem that you more often get shares in the low-return IPOs as discussed above.

3.3. **Market and funding liquidity.**

a. **Market liquidity.** You would pay more for the apartment if you are willing to have the same all-in costs, including the fees to the real estate agent when you buy, the present value of the fees to the real estate agent when you sell, and the expected costs associated with the longer time on the market. If a future buyer thinks the same way, the house will have a lower value when you need to sell and this lower "terminal value" further makes you want to pay less for the house. (As a result, the house price should be lower by the present value of all future extra costs, including those incurred by future owners.)

b. **Funding liquidity.** Modigliani-Miller would say that the capital structure does not matter so it should not affect the value that you need to put up more equity and take a lower loan. However, given that many buyers are financially constrained, a smaller access to credit lowers their ability or willingness to buy. Therefore, you might be willing to pay more for the apartment.

**c. Liquidity spirals and liquidity risk.**

- If the house can be expected to be more difficult to trade than the apartment, then the bank might be less willing to provide a large loan for house because it is more difficult for the bank to sell its collateral.
- If the apartment is more easy to borrow against, then it will be more easy to sell because potential buyers have better financing options.
- If suddenly there are many more properties for sale in this area than available buyers, then the prices will start to drop as sellers compete. Further, the time on the market will increase. These market conditions could lead banks to reduce their financing, which could scare off buyers or at least lower their willingness to pay, further exacerbating the situation, which then feeds on itself. Under the stated assumptions in this example, the market for houses might evolve worse because they were already less liquid before the event (especially if they also deteriorate more if left vacant).
- If houses have more liquidity risk in the sense that they face a larger risk of a sudden increase in the cost of selling and/or a sudden reduction in credit, then this lowers the price you are willing to pay for the house (given current liquidity conditions).
- If you are a "long-term buyer," i.e., expect to live in the property for 40 years, then market liquidity has little impact on the price you are willing to pay and, if you get a long-term loan from the beginning, then future funding liquidity is also not so important.

3.4. **Demand pressure.** Suppose that a significant fraction of the population of investors needs to buy a security, say a stock *ABC*, for reasons unrelated to the stock's fundamentals (its expected future earnings and dividends). For instance, suppose that an important stock market index suddenly gives a large weight to stock *ABC*.

a. The stock price should be (largely) unaffected in a perfectly efficient market.

b. In a market with limited arbitrage, the stock price is likely to be pushed up by the high demand. Indeed, other traders (which may be called "liquidity providers" or "arbitrageurs") will need to be encouraged to take the other side of this trade (for every buyer there is a seller). A high price implies a low

expected future return, and this low expected return is what encourages liquidity providers to step in and clear the market.

c. The price of another stock that is highly correlated to stock *ABC* (but not directly affected by the demand pressure) is also likely to increase a bit in the short term. To see why, note that liquidity providers who are now short *ABC* may want to hedge their position by buying correlated stocks, pushing up the price of the correlated stocks. As another way to see this, consider that owners of *ABC* who see that the price is now high may switch to a less expensive correlated stock.

   For evidence of these effects, see "Short- and Long-term Demand Curves for Stocks: Theory and Evidence on the Dynamics of Arbitrage," Journal of Financial Economics 2005, 75, 607–649 by R. Greenwood http://www.people.hbs.edu/rgreenwood/Nikkei225.pdf .

# *Efficiently Inefficient*

***How Smart Money Invests and Market Prices Are Determined***

## Solution to Exercises for
## *Portfolio Construction and Risk Management*

4.1. **Portfolio optimization.** Suppose that you were running a fund of hedge funds in 2003 and needed to allocate your capital between the various hedge fund styles. (Alternatively, you could be running a multi-strategy hedge fund and allocating capital across the various trading groups or running a pension fund allocating capital to various hedge funds.) Compute the excess return of each of the hedge fund indices.

a. and b. Sharpe ratios by time period:

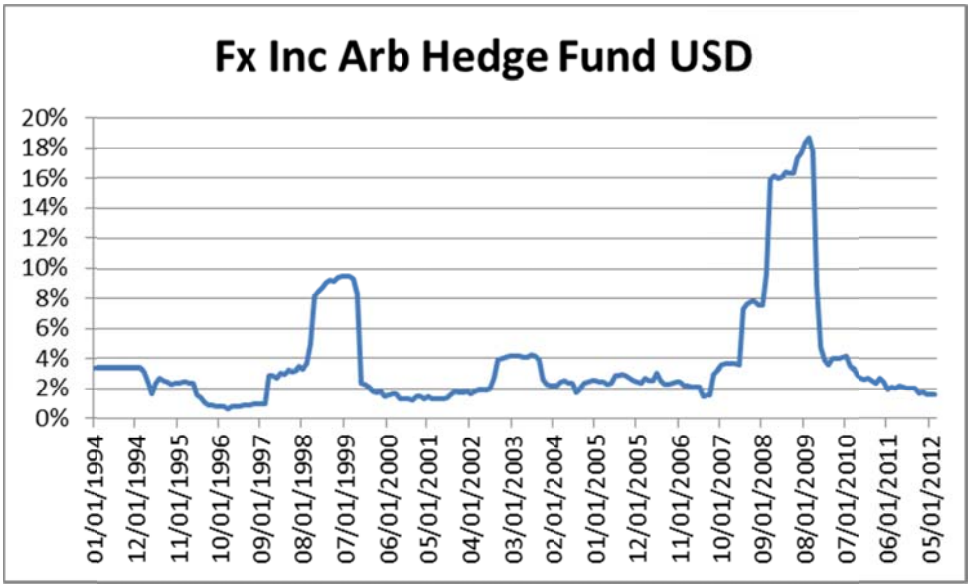
| | Equal weighted | Optimal in the first half |
|---|---|---|
| SR (1994-2003) | 1.07 | 2.32 |
| SR (2004-2012) | 0.47 | -0.06 |
| SR (full sample) | 0.77 | 0.38 |

We see that the optimized strategy does much better in 1994-2003 (the time period where it was optimized), but this performance was not realized as these portfolio weights were only known at the end of the time period. The optimized strategy does much worse in the second half of the sample, in fact realizing a negative alpha. The equal weighted portfolio appears more stable.

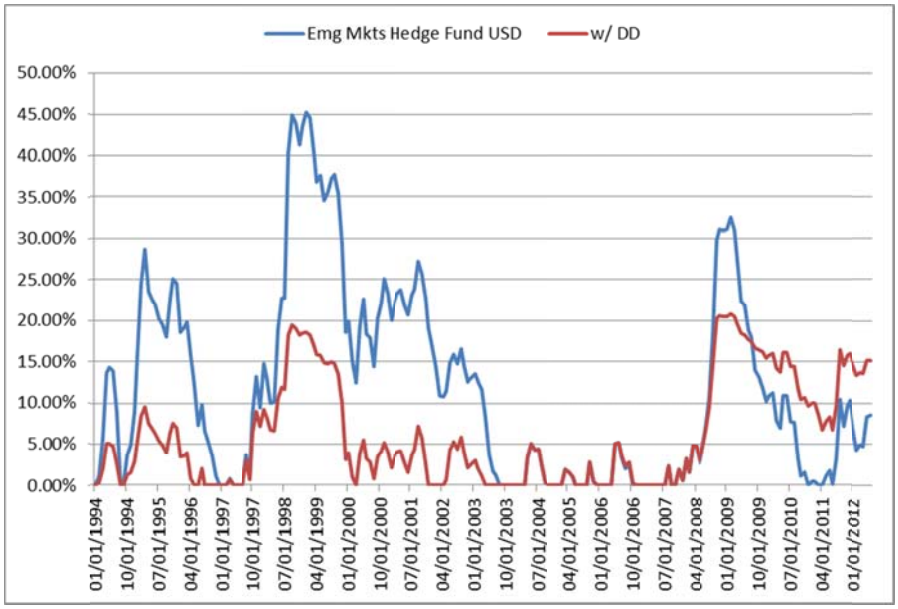
The optimized portfolio is clearly "over-fitted," having an extreme weight on equity market neutral (which later turns out to be heavily invested in the fraudulent fund run by Bernard Madoff) and small and even negative weights on other categories. Optimization often needs to be constrained and complemented with economic logic.

4.2. **Risk management and drawdown control.**

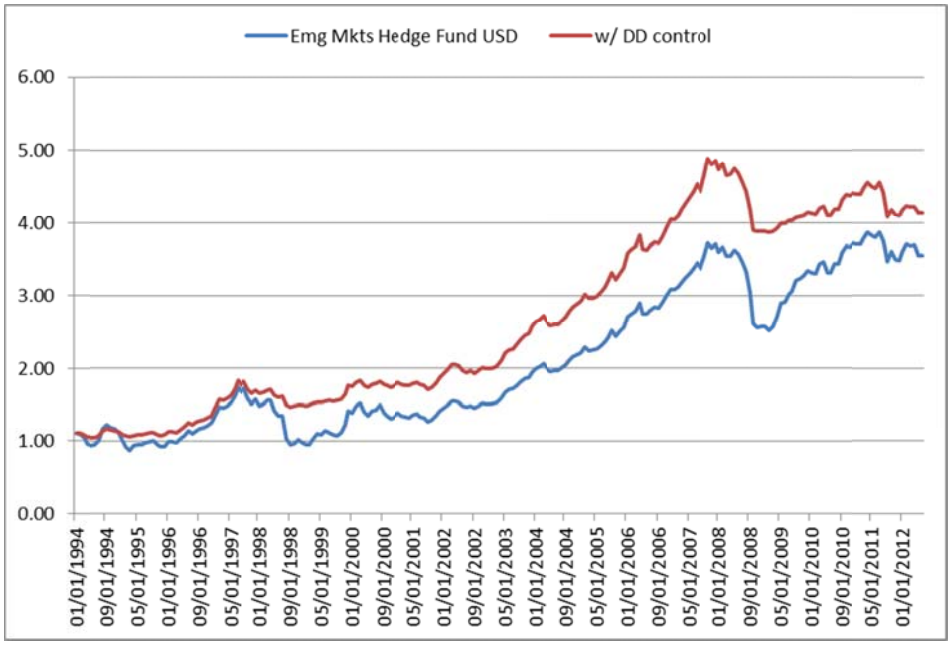
a. The rolling 12-month volatility of fixed income arbitrage is:




b. The drawdown of emerging markets hedge funds with and without drawdown control:




The cumulative returns of emerging markets hedge funds with and without drawdown control:




c. As seen below, the average SRs are similar with and without drawdown control. The return is about 7% higher on average without drawdown control, but this is because these strategies take less risk. The maximum drawdown is lower with drawdown control (21% on average vs. 32%), which is the point of drawdown control. Emerging markets shows the largest improvement.

The success of the drawdown scheme is not coming from simply taking less risk on average. To see that, note that even if the strategies are leveraged to realized the same average risk and return (i.e., the strategies with drawdown control are leveraged 7%), then the strategies with drawdown control continue to have smaller maximum drawdowns.

| | Ln/Sh Eq Hedge Fund USD | Eq Mkt Ntr Hedge Fund USD | Ded Sh Bs Hedge Fund USD | Global Mac Hedge Fund USD | Mngd Fut Hedge Fund USD | Emg Mkts Hedge Fund USD | Evnt Drvn Hedge Fund USD | Cnvrt Arb Hedge Fund USD | Fx Inc Arb Hedge Fund USD | DJCS Hedge Fund USD |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Without* DD control** | | | | | | | | | | |
| SR | 0.61 | 0.22 | -0.34 | 0.88 | 0.26 | 0.33 | 0.92 | 0.62 | 0.38 | 0.72 |
| Ave. return | 9% | 5% | -3% | 12% | 6% | 8% | 9% | 7% | 5% | 8% |
| Max(DD) | 22% | 45% | 64% | 27% | 18% | 45% | 19% | 33% | 29% | 20% |
| ***With* DD control** | | | | | | | | | | |
| SR | 0.61 | 0.19 | -0.34 | 0.98 | 0.19 | 0.57 | 0.81 | 0.51 | 0.29 | 0.68 |
| Ave. return | 8% | 5% | 0% | 10% | 5% | 8% | 8% | 6% | 4% | 8% |
| Max(DD) | 17% | 43% | 22% | 14% | 13% | 21% | 18% | 24% | 23% | 18% |

# *Efficiently Inefficient*

***How Smart Money Invests and Market Prices Are Determined***

## Solution to Exercises for *Trading and Financing a Strategy: Market and Funding Liquidity*

5.1. **Bid-ask spread.** The posted bid-ask spread is 2 cents, that is, 6 basis points of the mid price. If you buy 100 shares with a market order and immediately (i.e., before any new orders arrive or any existing orders are cancelled) sell them with a market order, then your P&L is $2.

5.2. **Limit order.** When a limit order to buy 150 shares at $34.50 arrives in the market, then no transactions occur. The order becomes the best bid and the bid-ask spread narrows to 1 cent.

5.3. **Walking the book.** A limit buy order for 2000 shares at $34.53 is executed with

- 300 shares at 34.51,
- 400 shares at 34.52,
- 1200 shares at 34.53, and
- 100 shares at 34.54.

The volume-weighted average execution price is 34.5255.

The bid-ask spread after the transaction is $34.54 - $34.49 = 5 cents.

5.4. **Market impact curve**:


The bid-ask spread is the most important number for a small order while market impact – i.e. a steep slope of the market impact curve – is important for large orders.

Market liquidity risk means that suddenly the bid-ask spread and/or the slope of the market impact curve can increase.

# *Efficiently Inefficient*

***How Smart Money Invests and Market Prices Are Determined***

## Solution to Exercises for *Discretionary Equity Investing*

This is not a full solution, but some comments and guidance based on the discussion in class. In 2014, we discussed the following stocks:

- RWE AG (Germany)
- Twitter Inc (USA)
- Prosafe ASA (Norway)
- HDFC Bank Ltd (India)
- Gazprom OAO (Russia)
- Eniro AB (Sweden)

7.1 **Valuation ratios.** Some data as of Oct. 2014:

| | RWE | Twitter | Prosafe | HDFC | Auriga | Gazprom | Eniro |
|---|---|---|---|---|---|---|---|
| P - price per share | 31.286 | 53 | 5.86 | 859.5 | 307.5 | 135.99 | 11.655 |
| EPS 2014 exp | 2.53 | -0.99 | 0.91 | 43.5 | 15.9 | 51.92 | 2.1 |
| EPS 2013 | -4.49 | -3.41 | 0.85 | 35.2 | 11.4 | 60 | 1.84 |
| P/E(2014 exp) | 12.4 | -53.5 | 6.4 | 19.8 | 19.3 | 2.6 | 5.6 |
| P/E(2013) | -7.0 | -15.5 | 6.9 | 24.4 | 27.0 | 2.3 | 6.3 |
| B per share 2013 | 12.6 | | 3.1 | 181.0 | 88.9 | 492.0 | 36.1 |
| B/M | 0.40 | 0.10 | 0.54 | 0.21 | 0.29 | 3.62 | 3.10 |
| Div 2014 exp | 0.99 | 0.00 | 0.59 | 8.40 | 2.57 | 8.46 | 0.00 |
| Div 2013 | 1.00 | 0.00 | 0.64 | 6.85 | | 7.20 | 0.00 |
| Div 2012 | 2.00 | 0.00 | 0.60 | 5.50 | | 5.99 | 0.00 |
| Div 2011 | 2.00 | 0.00 | 0.54 | 4.30 | | 8.97 | 0.00 |
| Div 2010 | 3.50 | 0.00 | 0.53 | 3.30 | 2.40 | 3.85 | 0.00 |
| Div 2009 | 3.50 | 0.00 | 0.40 | 2.40 | 2.40 | 2.39 | 0.00 |
| D(2014 exp) /P | 3.2% | 0.0% | 10.1% | 1.0% | 0.8% | 6.2% | 0.0% |
| D(2013) /P | 3.2% | 0.0% | 10.9% | 0.8% | 0.0% | 5.3% | 0.0% |

7.2 **Expected near-term dividends.** To estimate dividends, we need to estimate future earnings, apply the dividend policy (see below) and consider possible events which may change the dividend policy and/or the ability to pay. As discussed in class, it is unlikely that Twitter, Auriga, or Eniro will pay a dividend before 2017 since Twitter has little earnings and a focus on growth, Auriga may be delisted, and Eniro has a too high ratio of debt to EBITDA to justify dividends according to their dividend policy. Given the strong earnings and cash flow of the other firms, they will probably all pay dividends until 2017, but even with a detailed earnings prognosis a 90% confidence interval is bound to be wide. For RWE, a guess could be between 0.5 EUR and 2 EUR to be paid out in 2017.

7.3 **Valuation methods.** For the dividend paying firms, the discounted dividend model can be applied. We could in principle also use DDM for a firm like Eniro that is currently not paying dividends, but we would need to extrapolate earnings quite far into the future. Instead, one can consider various valuation ratios and relate to comparable firms. For HDFC it is challenging to estimate how many years the current growth can be sustained. For Twitter comparing P/S ratio to similar firms is an option. Auriga is a special case as it in the midst of liquidation as discussed in class, i.e., here the liquidation value is central.

Some issues which are not so obvious from financial data: RWE is challenged by German energy policy, Prosafe is exposed to a single market with potentially highly volatile rates, Gazprom have major agency issues and may be a value trap. Eniro is profitable, but in a declining market and loaded with debt, so it may also be a value trap. Gazprom is expected to adopt IFRS, which will likely boost reported earnings and dividends.

7.4 **Expected return.** Your estimated future return will reflect your view on the firm and there is no right answer. The intervals around your estimated future return should depend on the volatility and perhaps your confidence in your assessment of the firm's value and the probability that the market will recognize this value over the investment horizon. Also, think about why the market price may (or may not ) already incorporate your insights.

If returns are normally distributed, there is a 10% probability that returns will deviate more than 1.65 times the volatility from the mean (over one year). So your 90% confidence interval will be something like your expected return +/- 1.65×volatility. In any event, your 90% confidence intervals should be very wide.

Your required returns should reflect the systematic risk of the stock, i.e., whether its beta is high or low. It makes sense to use historical betas, but common sense as

well (e.g., possibly shrink betas toward 1). You also need an expected equity premium, e.g. 5% (see Chapter 10). Add the risk-free rate and possibly other return premia such as a liquidity premium for illiquid assets.

7.5 **Positions.** The positions that you take should of course reflect your analysis, long securities you like, short ones you dislike, and no position where you don't have a strong view.

7.6 **Portfolio construction.** Regarding possible hedges, global market risk could be hedged with futures. However, for each position, you can also hedge industry risk and country risk by taking a reverse position in a similar company (or portfolio of companies). Currency hedges should be considered and, in this connection, also think about the firms' exchange rate exposures. (E.g., Prosafe is listed in NOK, but its business is carried out in USD so which currency do you hedge?) Finally, you should size your positions in light of your volatility target of 15%.

**Dividend policies (from the company's websites)**

RWE

The Annual General Meeting on 16 April 2014 resolved a dividend of €1 per share for fiscal 2013. This means a dividend payment of 27 % of recurrent net income. Our previous dividend policy envisaged a payout ratio of 50 % to 60 %. We adjusted our payout ratio in reaction to the deterioration in earnings prospects in the conventional power generation business. RWE's dividend proposal for fiscal years from 2014 onwards will be within the range of 40 % to 50 % of recurrent net income.

Twitter

To date, Twitter has not issued a dividend.

Prosafe

On 24 August 2011, the Board of Directors resolved to adopt a new dividend policy. The level of dividend will reflect the underlying financial development of the company, while taking account of opportunities for further value creation through profitable investments. The new long-term dividend policy is a distribution of up to 75 per cent of the consolidated net profit paid the following year.

HDFC

Your Bank has had a dividend policy that balances the dual objectives of appropriately rewarding shareholders through dividends and retaining capital in order to maintain a healthy capital adequacy ratio to support future growth. It has had a consistent track record of moderate but steady increases in dividend declarations over its history with the dividend payout ratio ranging between 20% and 25%.

Auriga

It is Auriga's objective to ensure attractive, long-term returns via a combination of dividend distribution and a positive price development for the share.

The intention is to distribute at least DKK 2.40 per share each year and to supplement this with an extraordinary dividend such that 35% of the profit after tax and minority interests is distributed as dividend to the shareholders.

Suspension of dividend policy for 2012

It is decisive for Auriga to reduce debts and improve the cash resources so as to be able to seize any opportunities for growth and for strengthening the group's long-term value creation.

Consequently, the Board of Directors decided to deviate from the dividend policy announced and recommend to the annual general meeting that no dividend be paid for the financial year 2012. The proposal was adopted at the annual general meeting on April 16, 2013.

The intention is to maintain the dividend policy in future as it contributes to providing shareholders with an attractive, long-term return on their investment in Auriga, while at the same time considering the opportunities for continued development and growth.

Gazprom

The present clause stipulates that the dividend amount shall be calculated so as to ensure 17.5 to 35 per cent of the Company’s net income is paid out as dividends provided that the reserve fund has been fully replenished in line with the Company’s Articles of Association.

Eniro

The financial objective of reducing the company’s net debt in relation to EBITDA has precedence over shareholder dividends. The company’s objective is that net debt in relation to EBITDA will not exceed 2.0 times. This means that a reduction in the company’s debt continues to have priority.

# *Efficiently Inefficient*

***How Smart Money Invests and Market Prices Are Determined***

## Solution to Exercises for *Discretionary Equity Investing*

8.1. **Short selling and capital.**

a. Margin requirement = (10+8) × (20M) × 20% = 72 M.

Free cash (free equity) is 100M – 72M = 28 M.

The current balance sheet for the hedge fund written so that we see how the assets and liabilities fit together (everything in millions).:

| **Assets** | | **Liabilities** | |
|---|---|---|---|
| Cash from short positions | 200 | Short positions | 200 |
| Additional margin for shorts | 40 | Equity supporting short | 40 |
| Cash in money market account | 28 | Free equity | 28 |
| Long positions | 160 | Equity supporting long positions | 32 |
| | | Margin loan on long positions | 128 |

The balance sheet written more simply:

| **Assets** | | **Liabilities** | |
|---|---|---|---|
| Cash | 268 | Short positions | 200 |
| Long positions | 160 | Margin loan on long positions | 128 |
| | | Equity | 100 |

b. If the margin requirement for long and short positions changed to 30%, the margin requirement would be 18 × 20M × 30% = 108 M, i.e. position would not be sustainable.

The position would need to be scaled back to totally 100 M / 30% = 333M. This could be accomplished by reducing each position to 333 M / 18 = 18.5M.

c. P&L on the long positions = 160 M × 25% = 40 M.
P&L on the short positions = - 200 M × 10% = -20 M.
P&L from cash less financing = (268M-128M) × 4% = 5.6 M.

- NAV at the end of the year = 100M + 40M - 20M + 5.6M = 125.6M.

- Return of the hedge fund = 25.6%.

- The hedge fund performed well, both in absolute terms (it made a high return) and especially in terms of its alpha. The net position in stocks was $-40$M, i.e., a beta of $-0.4$ given the NAV of 100M. The realized alpha (which could of course be skill or luck) was

$$\alpha = R - \left(R^f + \beta(R^M - R^f)\right) = 25.6\% - (4\% - 0.4 \times 21.6\%) = 30.2\%$$

d. If the stocks that you shortsell are on special such that the short proceeds earn a return of 0%, then

P&L from cash less financing = (68M-128M) × 4% = -2.4 M.
NAV at the end of the year = 100M + 40M - 20M - 2.4M = 117.6M.
Return of the hedge fund = 17.6%.

8.2. **Short selling and valuation.**

a. Investor A buys a position measured in amounts of money given by $x^A$ so the number of shares that he buys is given by $x^A/P$ and similarly for investor B. Given that the total number of shares that they buy must equal the supply *s*, we have the equilibrium condition:

$$\frac{x^A}{P} + \frac{x^B}{P} = s$$

The investor demands are

$$x^A = \frac{E^A(R^e)}{\gamma^A \Omega} = \frac{W^A \frac{\mu^A - P}{P} P^2}{\sigma_\mu^2} = \frac{W^A(\mu^A - P)P}{\sigma_\mu^2}$$

$$x^B = \frac{E^B(R^e)}{\gamma^B \Omega} = \frac{W^B \frac{0 - P}{P} P^2}{\sigma_\mu^2} = -\frac{W^B P^2}{\sigma_\mu^2}$$

Plugging these investor demands into the equilibrium condition yields

$$\frac{W^A(\mu^A - P)}{\sigma_\mu^2} - \frac{W^B P}{\sigma_\mu^2} = s$$

which implies that

$$W^A \mu^A - P(W^A + W^B) = s\sigma_\mu^2$$

Solving for *P*, we get the equilibrium price without short-sale constraints

$$P = \frac{W^A \mu^A - s\sigma_\mu^2}{W^A + W^B}$$

b. Given that the price *P* is lower than $\mu^A$, we see that $x^A > 0$, that is, investor A is long. Investor B is short since $x^B < 0$.

c. If no investor is allowed to sell short, then $x^B = 0$ and investor A must hold all the shares, $\frac{x^A}{P} = s$. This implies an equilibrium price with short-sale constraints of

$$P = \frac{W^A \mu^A - s\sigma_\mu^2}{W^A}$$

This price is higher than that in a. since the numerator is the same (and assumed to be positive) and the denominator is smaller here due to the short-sale constraints.

d. A binding margin requirement for investor B implies that

$$x^B = -\frac{W^B}{M} = -\frac{W^B P}{m\sigma_\mu}$$

Market clearing implies

$$\frac{W^A(\mu^A - P)}{\sigma_\mu^2} - \frac{W^B}{m\sigma_\mu} = s$$

which implies

$$W^A\mu^A - \frac{\sigma_\mu W^B}{m} - W^A P = s\sigma_\mu^2$$

Hence, the equilibrium price with margin requirements is

$$P = \frac{W^A\mu^A - \sigma_\mu W^B/m - s\sigma_\mu^2}{W^A}$$

If the margin requirement $m$ is larger, then the price is higher.

e. If optimists get wealthier then the price increases (i.e., $P$ is increasing in $W^A$). If pessimists get wealthier then the price decreases (i.e., $P$ is decreasing in $W^B$).

f. **Short squeeze and liquidity spiral.**
   - Holding agents' wealth fixed, the increased margin requirement increases the price.
   - The increased price, leads to profits to optimists A and losses to pessimists B.
   - The fact that A is wealthier and B is poorer leads to a higher price.
   - The price increase and change in investor wealth feeds on each other, creating a kind of liquidity spiral called a "short squeeze" where pessimists are forced to close their short positions at ever higher stock prices.

# *Efficiently Inefficient*

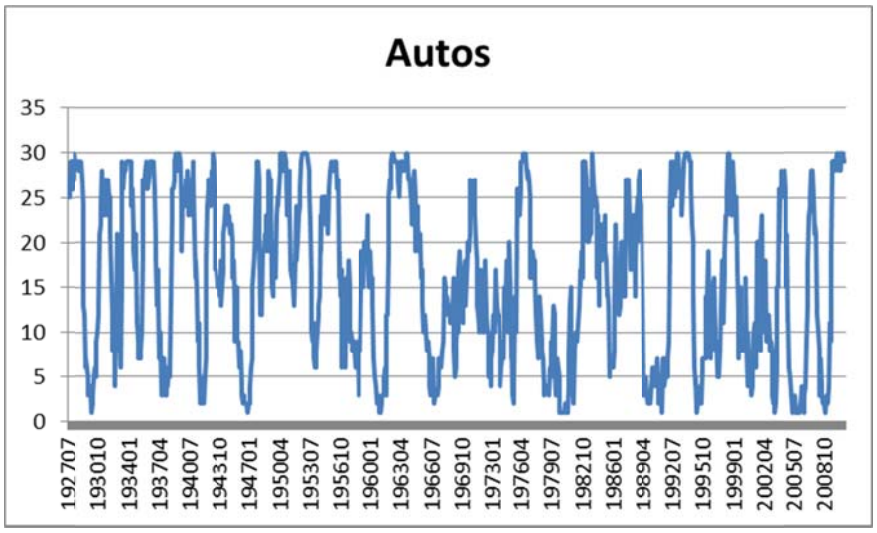
***How Smart Money Invests and Market Prices Are Determined***

## Solution to Exercises for *Quantitative Equity Investing*

## Backtesting Industry Momentum

9.1 Compute each industry's average rank (1=lowest past average return, etc.).

- Telcm has the lowest average rank and ElcEq has the highest.
- The average rank of these are 14.08 and 17.17.
- The rank of Autos industry over time:




- The industry ranks change a lot over time as seen in the figure and from the fact that the average ranks are similar across industries. Hence, industry momentum is *not* a static long-term bet on a few industries, but, rather, a very dynamic strategy. Hence, the turnover is expected to be relatively high over a year (but not each day).

9.2 **Winner portfolio.**

- The average monthly excess return on the winner 0.95%.
- The standard deviation of its monthly excess returns is 5.7%.
- The monthly Sharpe ratio is 0.17.
- The annualized Sharpe ratio 0.58.

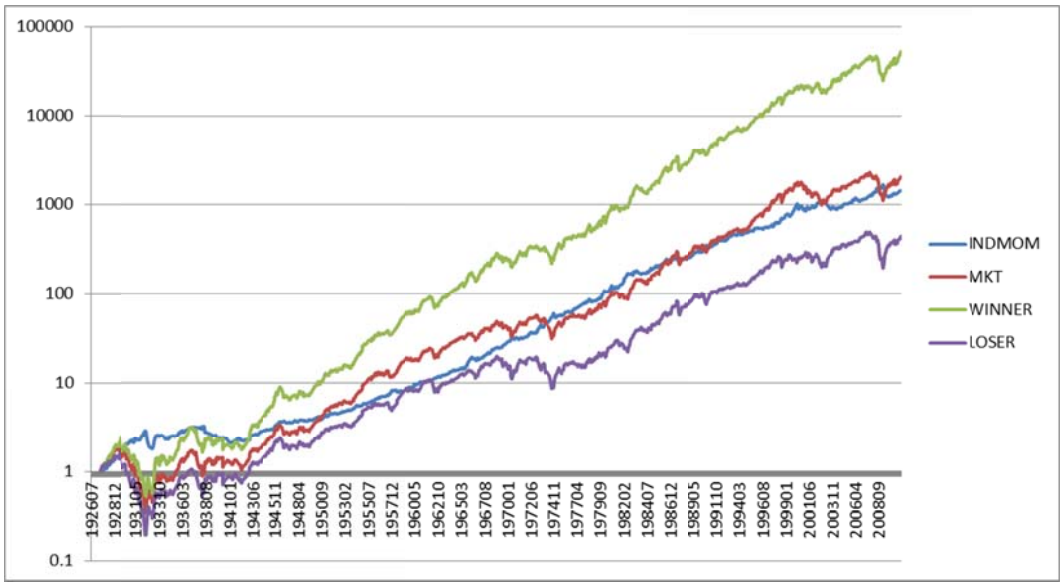
9.3 **Loser portfolio.**

- The average monthly excess return is 0.49%.
- The standard deviation of its monthly excess returns 5.9%
- The monthly Sharpe ratio is 0.08.
- The annualized Sharpe ratio is 0.28.
- The annualized Sharpe ratio of the overall market index is 0.39.

9.4 **Long-short ind-mom.**

- The annualized Sharpe ratio is 0.61.
- The market beta is -0.04 and the t-statistic of the market beta is -2.38.
- The monthly alpha is 0.49% and the t-statistic of the alpha is 5.82.
- The annualized alpha is 5.82%.
- The alpha is highly significant, meaning that the strategy appears to be helpful to investor who is otherwise only invested in the market (at least before transaction costs). The beta is negative and (marginally) significant, meaning that, if anything, the strategy acts as a (tiny) hedge against market risk. The Sharpe ratio is higher than that of the market. You can get an even higher Sharpe ratio if you combine ind-mom with the market in the right proportions.

9.5 **Cumulative return.** Even though ind-mom has the highest SR, it does not have the highest average return (or cumulative return) since it also has the lowest volatility. You can magnify its risk and expected return by using leverage.



9.6 **Ind-mom loss.** Industry momentum had a big loss in March, April, and May 2009. The market did very well those months, making such ind-mom losses a bit less painful for an investor who has most of his money in the market. The market had been falling during the global financial crisis of 2008-2009 so March-May 2009 was the big turning point. A momentum portfolio loses when trends reverse, in this case as the loser industries that had fallen the most during the crisis suddenly rallied the most.

9.7 **Extra question (not required)**. Historically, the best number of industries in the winner/loser portfolios has been 12, yielding an annualized Sharpe ratio of 0.66 for ind-mom. What may be more important is that the strategy is relatively robust to this choice, yielding a comparable performance for most choices of *N*.

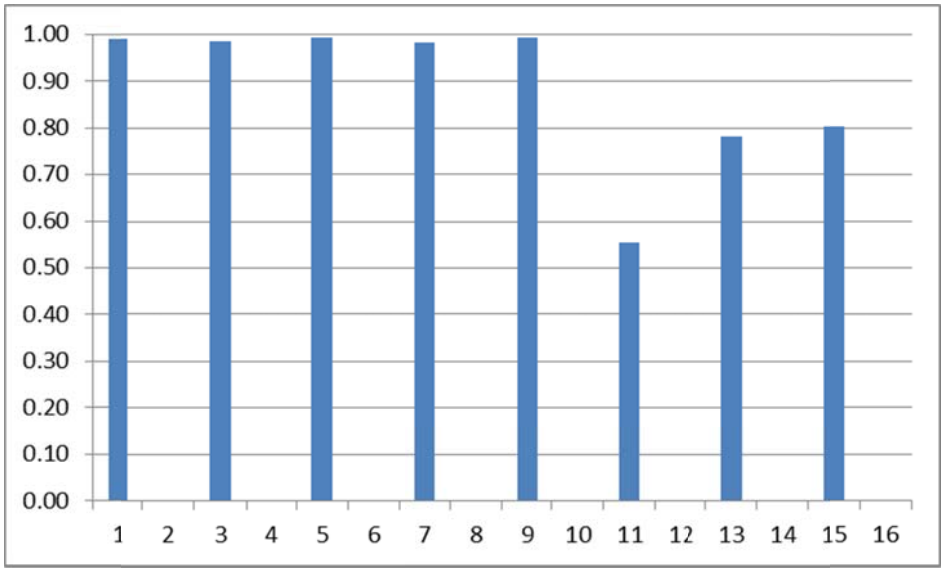
# *Efficiently Inefficient*

***How Smart Money Invests and Market Prices Are Determined***

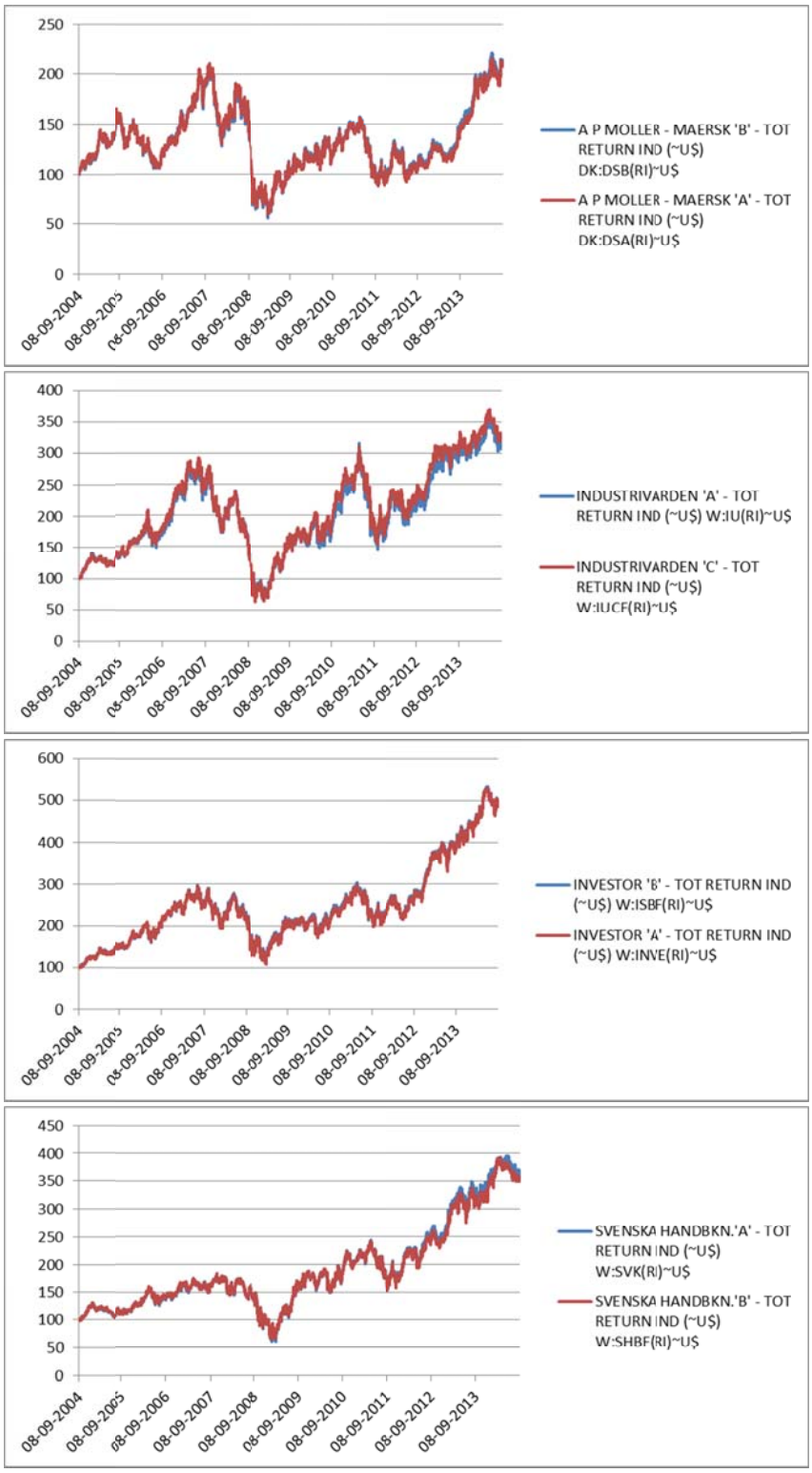
## Solution to Exercises for *Quantitative Equity Investing*

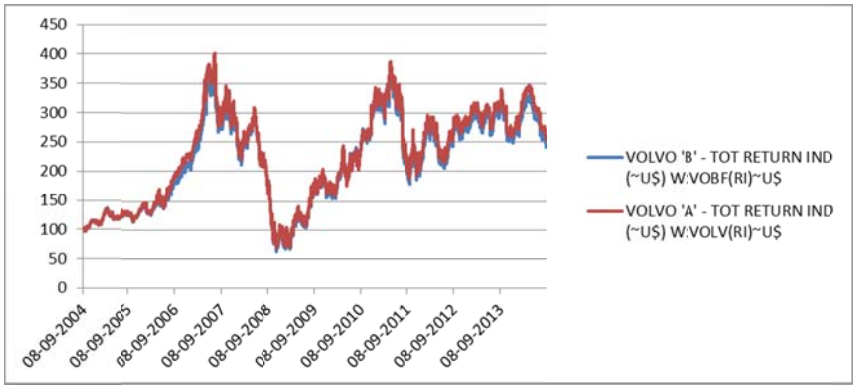
### Pairs Trading and Statistical Arbitrage

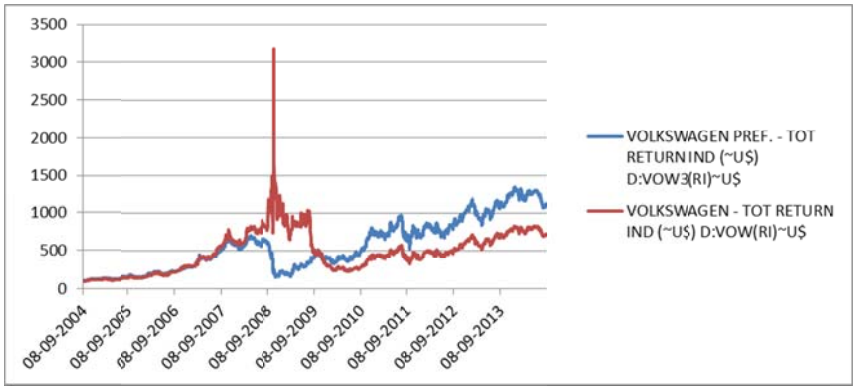
9.8 **Pair correlation.** In most cases, the pair stocks have a correlation close to 1, but not in all cases:

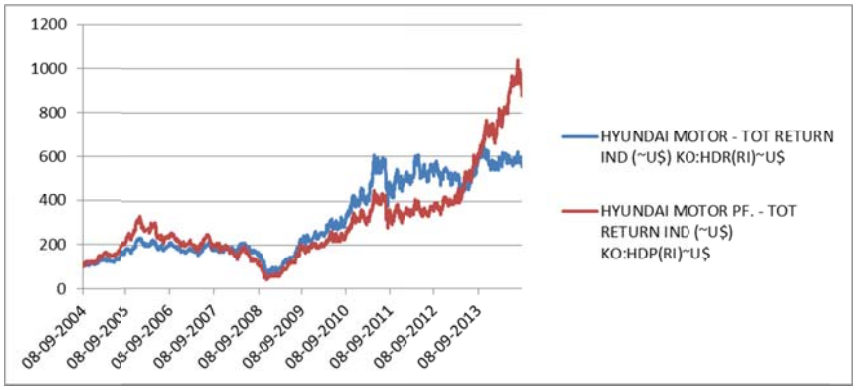


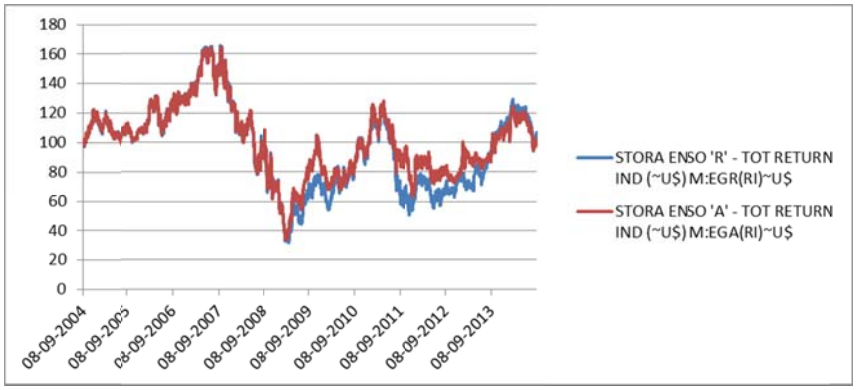
9.9 **Pair co-movement.** Most pairs move more or less in lockstep. Exceptions are Volkswagen, Hyundai and Stora Enso. Note the Volkswagen short squeeze.



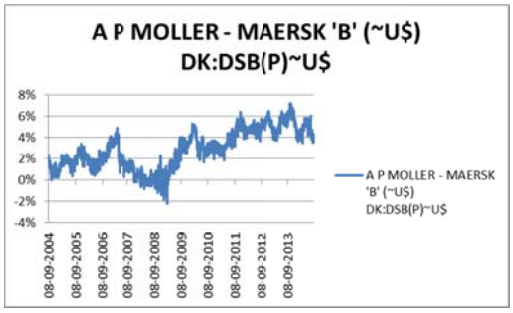

450
400
350
300
250
200
150
100
50
0
08-09-2004
08-09-2005
08-09-2006
08-09-2007
08-09-2008
08-09-2009
08-09-2010
08-09-2011
08-09-2012
08-09-2013
VOLVO 'B' - TOT RETURN IND (~U$) W:VOBF(RI)~U$
VOLVO 'A' - TOT RETURN IND (~U$) W:VOLV(RI)~U$

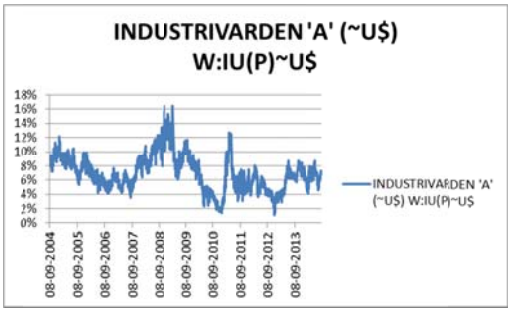

3500
3000
2500
2000
1500
1000
500
0
08-09-2004
08-09-2005
08-09-2006
08-09-2007
08-09-2008
08-09-2009
08-09-2010
08-09-2011
08-09-2012
08-09-2013
VOLKSWAGEN PREF. - TOT RETURN IND (~U$) D:VOW3(RI)~U$
VOLKSWAGEN - TOT RETURN IND (~U$) D:VOW(RI)~U$

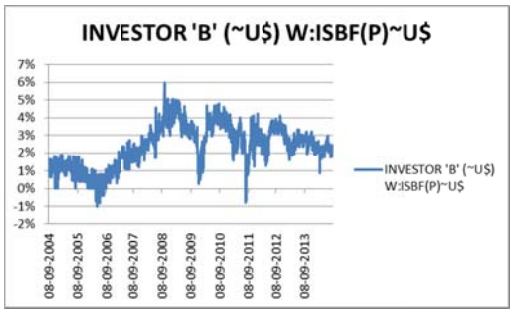

1200
1000
800
600
400
200
0
08-09-2004
08-09-2005
08-09-2006
08-09-2007
08-09-2008
08-09-2009
08-09-2010
08-09-2011
08-09-2012
08-09-2013
HYUNDAI MOTOR - TOT RETURN IND (~U$) KO:HDR(RI)~U$
HYUNDAI MOTOR PF. - TOT RETURN IND (~U$) KO:HDP(RI)~U$

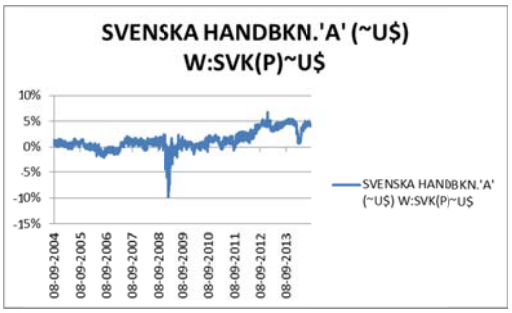

180
160
140
120
100
80
60
40
20
0
08-09-2004
08-09-2005
08-09-2006
08-09-2007
08-09-2008
08-09-2009
08-09-2010
08-09-2011
08-09-2012
08-09-2013
STORA ENSO 'R' - TOT RETURN IND (~U$) M:EGR(RI)~U$
STORA ENSO 'A' - TOT RETURN IND (~U$) M:EGA(RI)~U$

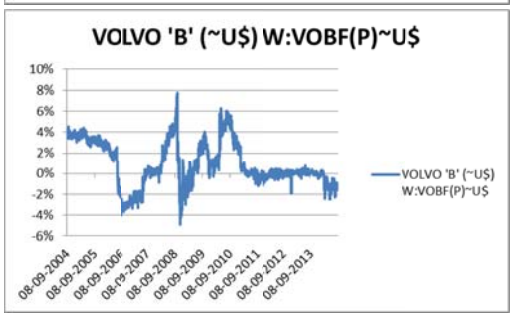
9.10 **Spreads.** The pair spreads show interesting patterns. For instance, Industrivärden seems to fluctuate around a small premium on the A share, with trading opportunities when the spread deviates from this level. Same for Investor, APM, Volvo and Svenska Handelsbanken. Stora Enso R occationally trade at a discount but in other periods there is no discount. For Hyundai the premium on the ordinary share fluctuates a lot but in what seems to be long waves.

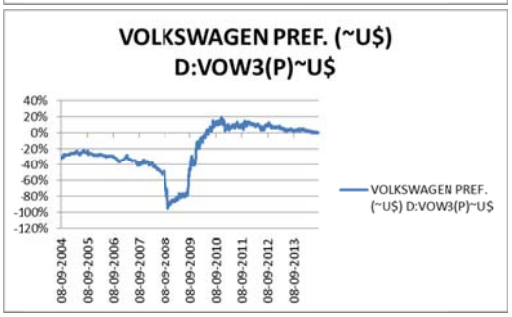


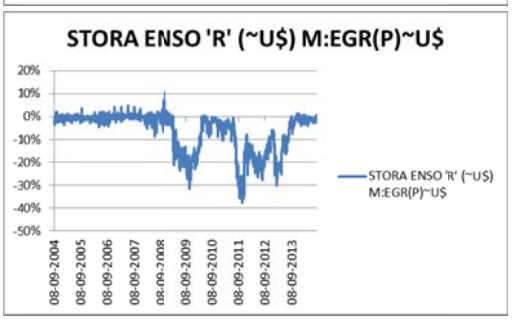







9.11 **Pairs trading based on absolute prices.**

a. The return on the strategy consists of two components: the difference in dividend yield between the two stocks (i.e., the carry) and the relative price change between the two stocks.

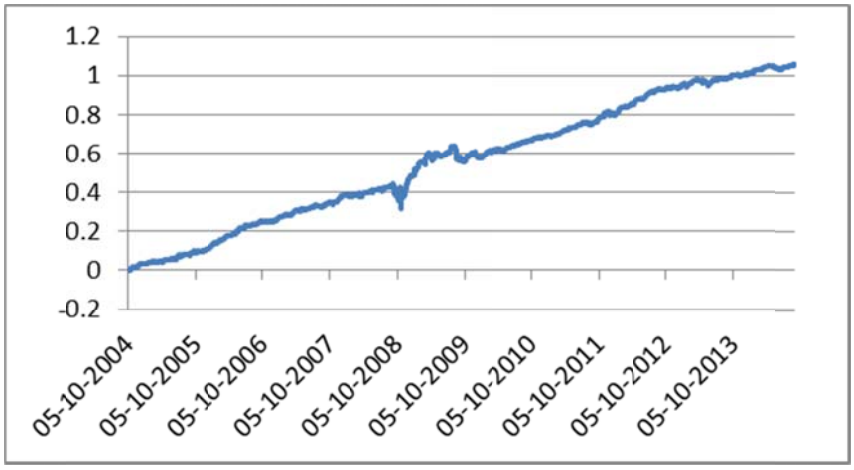
   The difference in dividend yield is by definition positive. I.e., the strategy always has a positive carry. (You don't need to consider dividends explicitly in the calculations as dividends are included in the return index.)

   Over any given year, the relative change in prices can go either way as the price spread may narrow or widen. If you expect that the spread narrows, then you expect a possible profit from this return component. Alternatively, if you expect that the price spread will fluctuate around a non-zero level, then the price change component should average close to zero over the long term. Such a non-zero price spread can arise as an efficiently inefficient compensation for difference in the stocks' liquidity and/or control rights.

b. All pair trade are profitable on average, except the one on Investor. However, for each pair, the profit is not statistically significantly different from zero. The average SR is 0.27.
c. The equally-weighted portfolio of pairs strategies has a SR of 0.33. The t-statistic of the average return is 0.99, not significantly different from zero, which could be due to the short time series and, limited amount of data, and infrequent turnover.
d. If you were to implement this strategy in practice, you would incur transaction costs, short-sale costs, and funding costs.

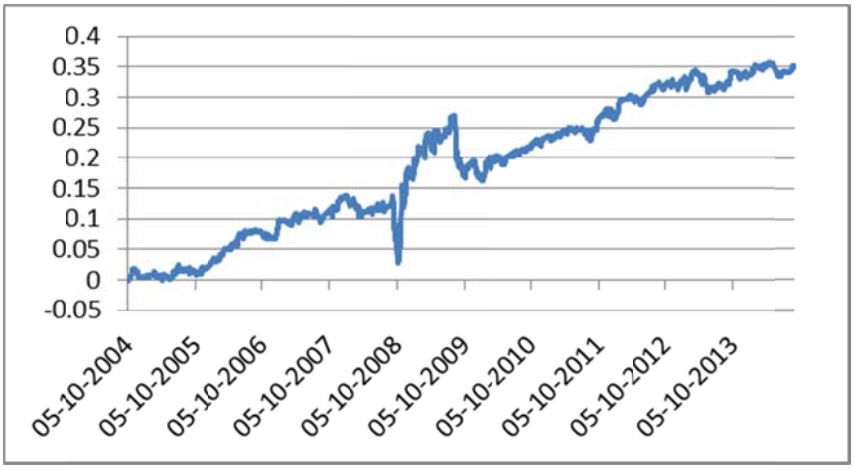
9.12 **Pairs trading based on "unusual" price spreads: mean-reversion.**

a. This strategy is betting on mean reversion of the spread between the two stocks.
b. Assuming you can observe closing prices and trade on these prices same day, the cumulated profits from the equal-weighted portfolio is:




The daily SR is 0.10 and the annualized SR is 1.61 (using 252 trading days per year).

c. Alternatively, assuming that you have to wait one day from you observe close prices until you trade, the annualized SR of the portfolio is 0.64 and its cumulative return is:



# *Efficiently Inefficient*

***How Smart Money Invests and Market Prices Are Determined***

## Solution to Exercises for *Global Macro*

11.1 **Investment currencies and funding currencies.**

- Japan has the lowest average rank of 1.74, i.e., it is most often a "funding currency" with the lowest interest-rate.
- Switzerland is the second to most often funding currency with a rank of 1.91.
- New Zealand is most often "investment currency," i.e. highest average rank.
- Australia is second to most often investment currency.
- Rank of the US over time:


11.2 **Carry positions.**

- The average position in New Zealand is 0.76.

11.3 **Carry trade return.** Compute the excess return on each position, and add these up to get the excess return of the entire portfolio in any month. Make sure to get the timing right.

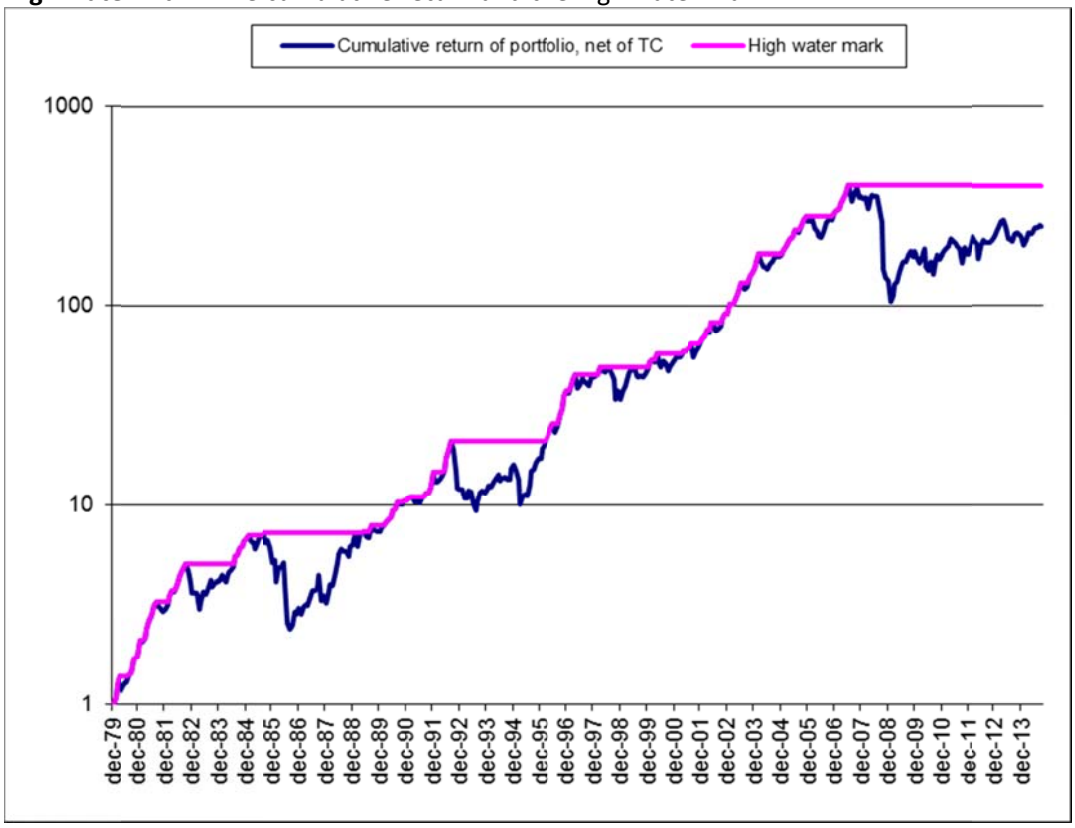
- The annualized average excess return of the portfolio is 15.2%.
- The annualized standard deviation is 28.7%
- The annualized SR is 0.53.

- The skewness of monthly returns is -1.1.
- The excess kurtosis of monthly return 2.76.
- These numbers show a high return and SR for such a simple strategy, but also significant crash risk as seen in the negative skewness and kurtosis.

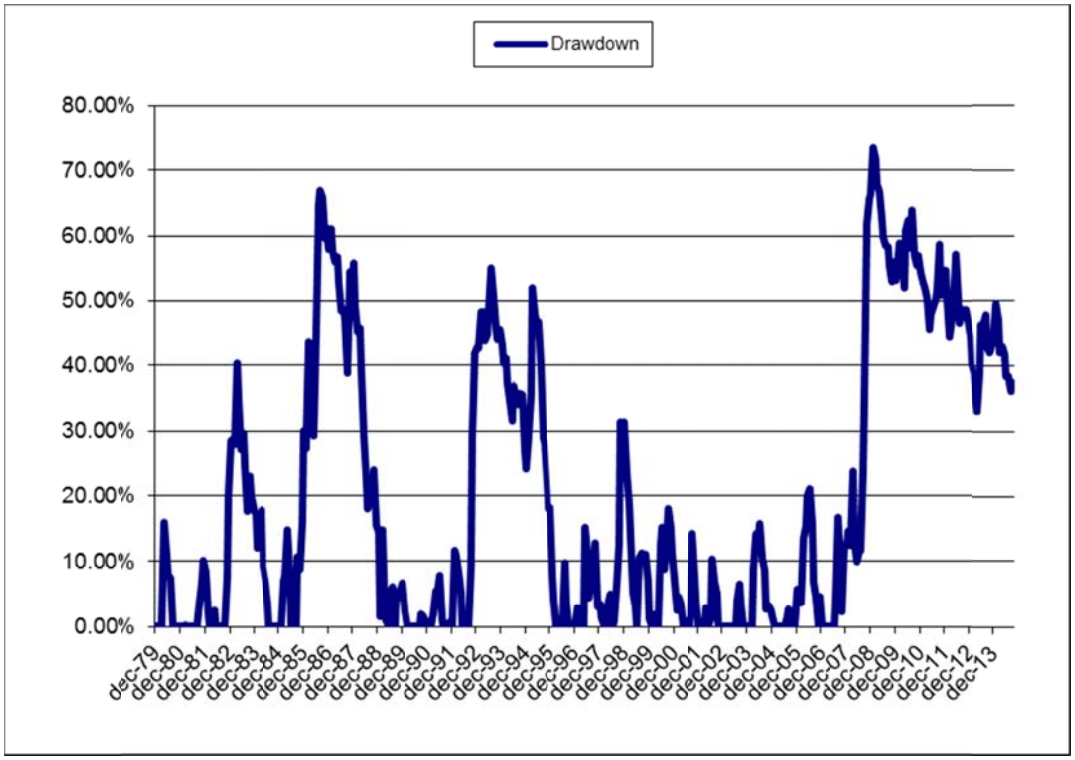
11.4 **Transaction costs.**

- The annualized average net return of the portfolio is 14.8%.
- The annualized net SR is 0.52.
- The transaction costs are low for two reasons: 1) currency markets are very liquid, and 2) the carry trade has a low turnover since interest rates are very persistent. A macro trader could nevertheless incur significant transaction costs on the carry trade if he is forced to unwind (or rebalance) a large position quickly during a liquidity crises (which is costly because all trading is more costly at such times and because trading a large position is especially costly) or if he trades more illiquid currencies such as emerging market currencies. Indeed, the transaction costs in the spreadsheet may be most relevant for a patient trader who can trade gradually, which leads some traders to slowly take on large positions, but these large positions may sometimes need to be traded quickly.

11.5 **High water mark.** The cumulative return and the high water mark:



11.6 **Drawdown.** The drawdown, $DD_t = (HWM_t - P_t) / HWM_t$, where $P$ is the cumulative return and $HWM$ is the high water mark is:




11.7 **Timing the carry trade.** Some macro traders try to time the carry trade, hoping to earn the carry in calm times and quickly get out of their positions (or even reverse them) when currency market volatility increases and the carry trade may suffer. Of course, this fickle behavior of macro traders itself creates a risk of a carry unwind, and not all macro traders can unwind before the others. On the other hand, a time of high risk may also be a time of opportunity. To determine risk and expected return, macro traders may look at volatility, change in volatility, past returns, or more fundamental factors such as the currency valuations (e.g., vs. PPP), currency reserves, trade surplus, or sovereign risk. You can backtest various versions of these and other ideas (but note that the way in which macro traders try to unwind their positions when carry losses start may change over time).

# *Efficiently Inefficient*

***How Smart Money Invests and Market Prices Are Determined***

## Solution to Exercises for *Managed Futures: Trend-Following Investing*

12.1 **Direction of the estimated trend.** The average trend direction indicator is:

| Commodities | | | Equities | | | Bond futures 10Y | | | Currencies | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALUMINUM | CORN | GOLD | Germany | UK | US | Germany | UK | US | Australia | Japan | UK |
| -0.09 | -0.31 | -0.09 | 0.32 | 0.47 | 0.51 | 0.46 | 0.33 | 0.37 | 0.23 | 0.05 | 0.12 |

12.2 **Time series momentum: constant notional.**

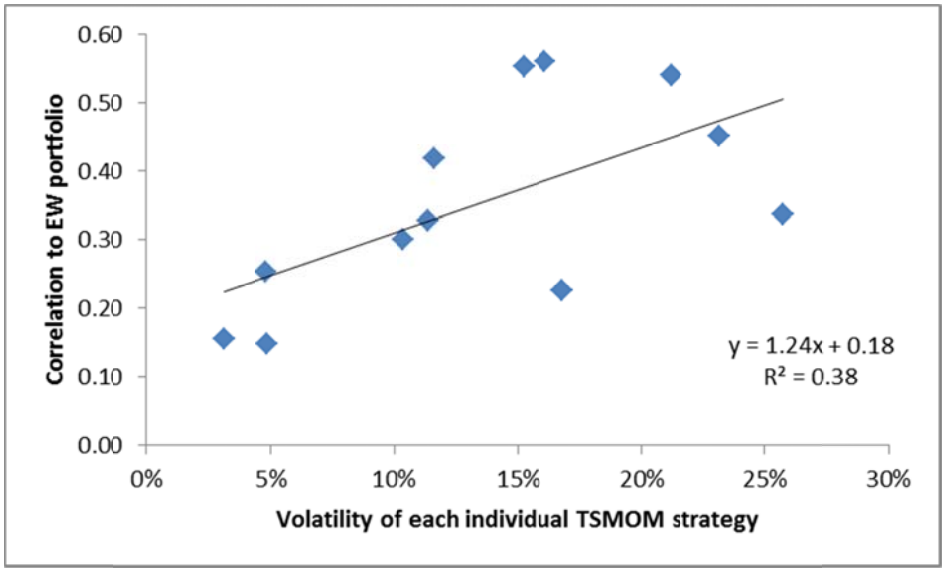
a. The average SR of each of these strategies is 0.36.

b. The SR of the equal-weighted portfolio is 0.82, much higher than the average SR due to the benefits of diversification.

c. The correlation between each individual strategy and the equal-weighted portfolio

| Commodities | | | Equities | | | Bond futures 10Y | | | Currencies | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALUMINUM | CORN | GOLD | Germany | UK | US | Germany | UK | US | Australia | Japan | UK |
| 0.45 | 0.34 | 0.23 | 0.54 | 0.56 | 0.55 | 0.15 | 0.15 | 0.25 | 0.42 | 0.33 | 0.30 |

Scatter plot where the x-axis has each strategy's volatility and the y-axis has its correlation to the equal-weighted portfolio:




The more volatility strategies have a bigger impact on the overall portfolio and, therefore, they also become more correlated to the overall portfolio. Hence, the success of the portfolio depends the most on that of the most volatile strategies.

d. In reality, you cannot compute a trading signal based on the end-of-month closing price and trade at the closing price at the same time. A more realistic approach would be to base the signal on the price a day before the assumed trading time, or an hour before, or a shorter/longer time period depending on the execution method that you intend to use.

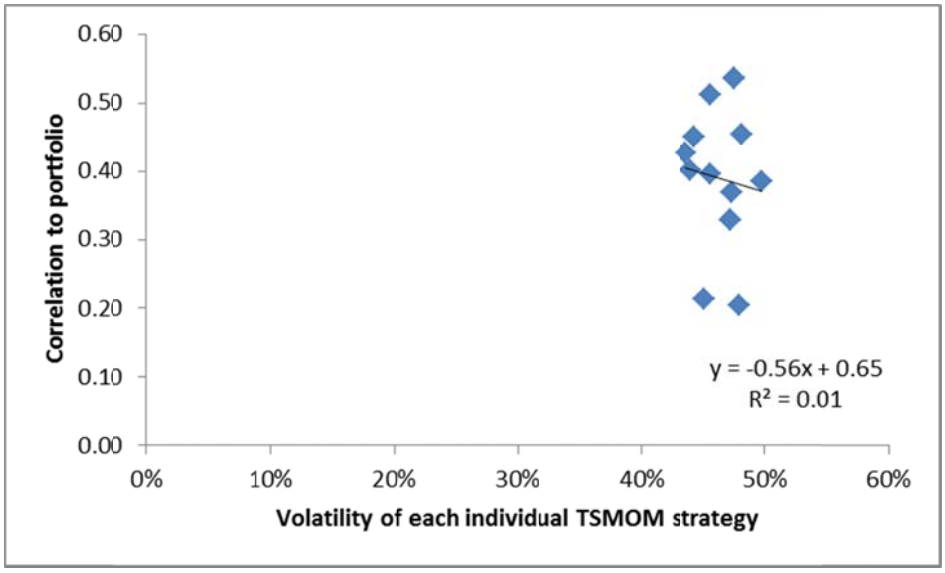
   Backtesting the same strategy where you wait a month from the generation of the signal until you put on the trade, we have a SR of 0.59 if we trade on the 12 months return after 1 month and a SR of 0.69 if we use the 11 months return after one month. In either case, we see that the effect on the performance is non-trivial. The latter method may be better because it has the same end-point as in a.-c., namely 1 year before the trade time, and therefore is not impacted by potential reversal effects beyond a year.

12.3 **Time series momentum: risk balanced.**

a. The average SR of each of these strategies is 0.41? This average SR is slightly above that in 12.2.a., which could be due to noise or to the benefits of keeping volatility more stable over time.

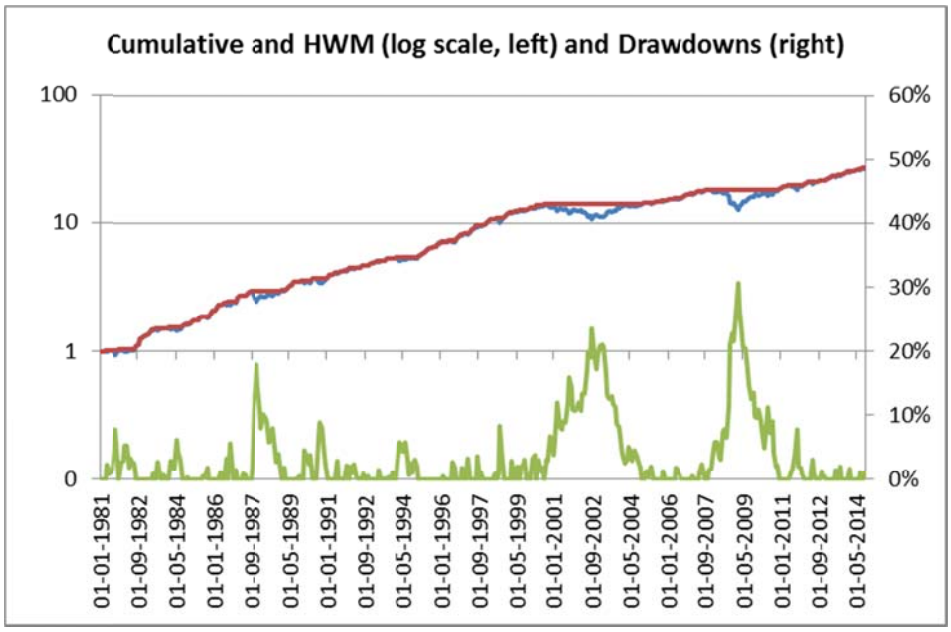
b. The SR of the risk-balanced portfolio is 1.05, higher than in 12.2.b. and the difference is higher than the average difference between the individual strategies that we saw in a. This improvement is due to the greater benefits of diversification achieved through the equal risk weighting. One risk of this approach is that leverage is varying and could become too large, especially is volatility is poorly estimated.

c. Scatter plot where the x-axis has each strategy's volatility and the y-axis has its correlation to the equal-weighted portfolio (make sure that the x-axis starts at zero). We see that there is virtually no relation between volatility of correlation (R2=0.01).




12.4 **Return during 60/40 drawdowns.**

a., b., and c.:



| | First Major Drawdown | | | Second Major Drawdown | | | Third Major Drawdown | | |
|---|---|---|---|---|---|---|---|---|---|
| | DD | Recovery | Full | DD | Recovery | Full | DD | Recovery | Full |
| **60/40** | -17.9% | 24.8% | 2.4% | -23.5% | 31.2% | 0.3% | -30.8% | 46.0% | 1.0% |
| **MF const notional** | -2.0% | 33.4% | 30.8% | 105.3% | 27.4% | 161.5% | 42.0% | -11.2% | 26.1% |
| **MF risk balanced** | 3.5% | 39.2% | 44.1% | 96.8% | 49.0% | 193.2% | 40.3% | 4.6% | 46.7% |
| | | | | | | | | | |
| **ANNUALIZED** | | | | | | | | | |
| **60/40** | -54.8% | 20.8% | 1.7% | -12.1% | 13.3% | 0.1% | -24.2% | 22.8% | 0.3% |
| **MF const notional** | -7.8% | 27.9% | 20.8% | 41.3% | 11.8% | 25.4% | 30.2% | -6.2% | 7.6% |
| **MF risk balanced** | 14.9% | 32.6% | 29.3% | 38.4% | 20.2% | 28.8% | 29.1% | 2.5% | 12.9% |
| | | | | | | | | | |
| **Number of days** | 91 | 428 | 519 | 760 | 792 | 1552 | 485 | 672 | 1157 |
| **Dates** | 8/31/1987 | 11/30/1987 | 1/31/1989 | 8/31/2000 | 9/30/2002 | 11/30/2004 | 10/31/2007 | 2/27/2009 | 12/31/2010 |

d. During the 1987 crash, the MF strategy does not profit during the initial DD since it happens all of a sudden, whereas MF profits during the other two crises that evolve gradually. The beginning of a recovery is, by definition, a trend reversal, which should lead to loses for MF, but the continuing recovery can lead to profits. We see that the MF strategy profits over the full recovery periods in the first two events, but not the last one. In each of the tree major crises, the MF profits during the full drawdown period.

# *Efficiently Inefficient*

***How Smart Money Invests and Market Prices Are Determined***

## Solution to Exercises for *Fixed-Income Arbitrage*

14.1 **Price and yield.** The price of the 2-year zero-coupon bond is

$$P_{zero} = \frac{100}{(1.046)^2} = 91.40$$

The yield to maturity of the 3-year zero coupon bond is

$$Y = (100/89.11)^{1/3} - 1 = 3.92\%$$

14.2 **No arbitrage pricing.** Value of the annual-pay coupon bond:

$$P_{coupon} = 0.05 \times 96.32 + 1.05 \times 91.40 = 100.78$$

14.3 **Fixed income arbitrage.** Suppose that the coupon bond trades at a price of $101.00.

a. What arbitrage trade would you do? You should short the coupon bond since its price is above the fair value. There are several ways to structure the trade. First, you could short 1 coupon bond and hedge it by buying 0.05 1-year zero-coupon bonds and 1.05 2-year zero-coupon bonds. This generates in immediate cash flow of $0.22 and cash flows that balance in years one and two. Alternatively, you can do this same, except that you also invest the $0.22 in 2-year coupon bonds such that your total position in 2-year zeros is 1.0524 bonds. This position generates an immediate cash flow of zero, balanced payments at time 1, and a profit at time 2 of $0.24 (the future value of $0.22). From now on, I consider this second method (since having the P&L in the future makes it simpler to discuss returns).

b. Suppose that you hold this position until maturity in two years. The profit in dollars is $0.24 as mentioned above. The value of the long side is $101 and the margin requirement is $20.2. Therefore, we have the 2-year returns of, respectively, 0.24/101 and 0.24/20.2, which are annualized using the formula for geometric compounding:

| | P&L in dollars | P&L in % over 2 years | P&L in % annualized |
|---|---|---|---|
| Profit relative to long side | 0.24 | 0.23% | 0.12% |
| Profit relative to margin | 0.24 | 1.17% | 0.58% |

c. Suppose that, after one year, the yield to maturity on all bonds is 5%. Calculating the return on each bond, we get the new value of the portfolio, implying the following return:

| | P&L in dollars | P&L in % over 1 year | P&L in % annualized |
|---|---|---|---|
| Profit relative to long side | 0.23 | 0.22% | 0.22% |
| Profit relative to margin | 0.23 | 1.11% | 1.11% |

Given that all bonds have a yield to maturity of 5%, the mispricing has disappeared and, therefore, we naturally earn the full time-1 value of the mispricing already at this time.

d. Suppose that the yield to maturity on all bonds becomes 5% already 1 month after you put on the trade. What is the profit or loss in dollars at this time? Return:

| | P&L in dollars | P&L in % over 1 month | P&L in % annualized |
|---|---|---|---|
| Profit relative to long side | 0.22 | 0.21% | 2.59% |
| Profit relative to margin | 0.22 | 1.07% | 13.57% |

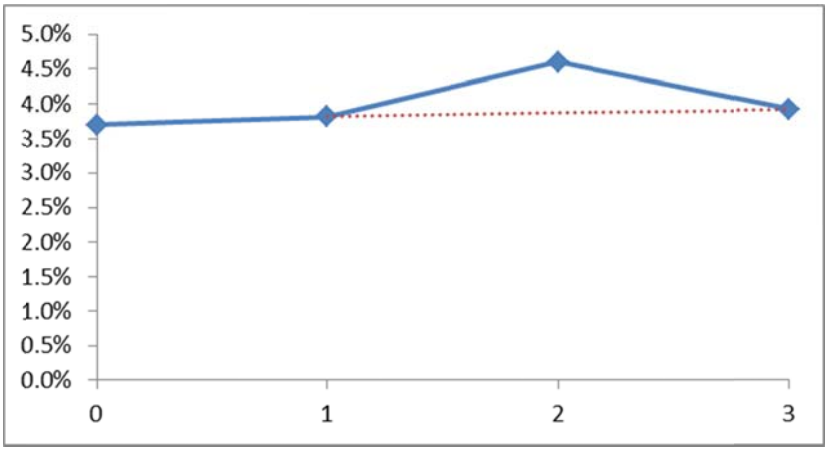
We see that a faster convergence leads to a higher annualized return.

14.4 **Forward rates and directional fixed income trading.**

a. The forward rate from time 1 to time 2 is 5.39%.

b. You believe that the 1-year interest rate will be 4% in one year. You go long the 2-year zero-coupon bond, say long one bond. You finance this by shorting 0.95 1-year bonds. If the 1-year rate indeed turns out to be 4% next year, then you make $1.26.

14.5 **Yield curve.**



14.6 **Duration.** Compute the duration and modified duration of each of the four bonds. If each bond's yield to maturity immediately increases by 1 percentage point, approximately how many dollars will each price decline?

| Type of bond | Maturity | Coupon | Price | YTM | Duration | Modified D | Price at new YTM | % price change, exact | % price change, approx |
|---|---|---|---|---|---|---|---|---|---|
| Zero coupon | 1 | 0 | 96.32 | 3.82% | 1 | 0.96 | 95.40 | -0.95% | -0.96% |
| Zero coupon | 2 | 0 | 91.40 | 4.60% | 2 | 1.91 | 89.68 | -1.88% | -1.91% |
| Zero coupon | 3 | 0 | 89.11 | 3.92% | 3 | 2.89 | 86.59 | -2.83% | -2.89% |
| Annual-pay coupon | 2 | 5% | 100.78 | 4.58% | 1.95 | 1.87 | 98.93 | -1.84% | -1.87% |

14.7 **Yield curve trading.** The average of the yields of the 1-year and 3-year zero-coupon bonds is 3.87%, which is shown at the dotted line in the yield curve graph above.

a. We go long one 2-year bond. As discussed in the book, one way to structure a butterfly trade is as follows: For each of the 1-year and 3-year bonds, choose the absolute position size such that the position times the price times the modified equals 0.5 times the same product for the 2-year bond, that is, $x^1 \, \overline{D}^1 \, P^1 = x^3 \, \overline{D}^3 \, P^3 = -0.5 \times 1 \, \overline{D}^2 \, P^2$. This means that the short 0.94 1-year bonds and 0.34 3-year bonds.

b. **Level change up**. The P&L (i.e., the change in the value of our portfolio) if the yields of the three zero-coupon bonds immediately change to 4.82%, 4.87%, and 4.92% is $1.25 (or $1.28 based on the approximations of bond values using duration).

c. **Level change down**. The P&L if the yields of the three zero-coupon bonds immediately change to 2.82%, 2.87%, and 2.92% is $1.33 (or $1.28 based on the approximations of bond values using duration).

d. **Slope change up**. The P&L if the yields of the three zero-coupon bonds immediately change to 2%, 3%, and 4% is $1.31 (or $1.28 based on the approximations of bond values using duration).

e. **Slope change down**. The P&L if the yields of the three zero-coupon bonds immediately change to 4%, 3%, and 2% is $1.28 (or $1.28 based on the approximations of bond values using duration).

f. **Bigger kink**. In all the yield curves in questions a-e, the kink was eliminated (the 2-year yield is the average of the 1 and 3 year yields). This is why we made money in each of these cases. The P&L if the yields of the three zero-coupon bonds immediately change to 3.82%, 5%, and 3.92% is $ -0.70 (or $ -0.70 based on the approximations of bond values using duration).

# *Efficiently Inefficient*

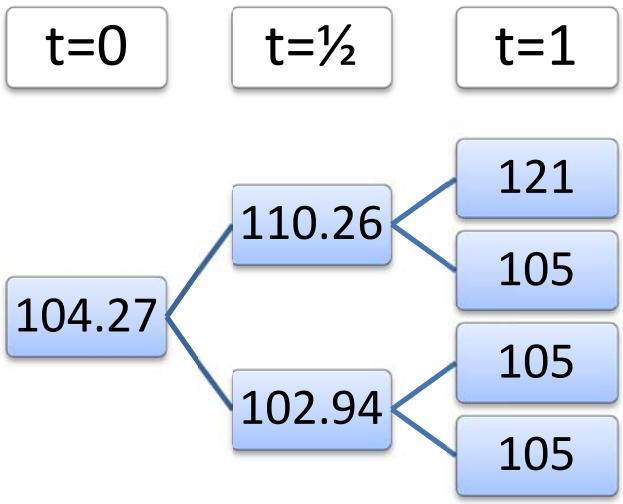
***How Smart Money Invests and Market Prices Are Determined***

## Solution to Exercises for *Convertible Bond Arbitrage*

15.1 **Theoretical value of the convertible bond:**

a. The convertible bond should be converted only at maturity and only in the highest state since the stock price must be above 105 for conversion to be optimal.

b. The theoretical value of the convertible bond at each state in the tree is




15.2 **Convexity.** At time 0, a hedge fund buys a convertible for the price computed in 1 and optimally hedges the position.

a. If that the stock prices unexpectedly jumps to a new value *S* immediately at time 0 then the hedge fund's P&L at time 0 is:

| Stock price | Convertible | Hedged conv. P&L | |
|---|---|---|---|
| | | starting at 100 | starting at 90 |
| 90 | 101.74 | 2.35 | **0.00** |
| 95 | 103.01 | 1.17 | 0.61 |
| **100** | **104.27** | **0.00** | 1.21 |
| 105 | 107.80 | 1.09 | 4.08 |
| 110 | 111.57 | 2.41 | 7.18 |

b. Suppose that the stock price jumped down to $S$=90 and that the hedge fund re-adjusts its hedge at this price level. Then the stock price jumps back up 100. The P&L from the jump up in price is 1.21 as seen in the table above.

c. Suppose instead that the stock price remains 100, but that the volatility changes immediately at time 0. Specifically, suppose that the jump sizes change to up=20% and down=-10%. What is the P&L of the hedge fund? What is the P&L if the jump sizes change to up=5% and down=-3% ?

| Volatility | Convertible | Hedged conv. P&L |
|---|---|---|
| low | 102.89 | -1.38 |
| **medium** | **104.27** | **0.00** |
| high | 108.30 | 4.03 |

15.3 **Cheapness.** Suppose that stock market evolves as in the initial tree above, but the market price of the convertible bond differs from its theoretical value. At time 0, the convert has a price of 101. A hedge fund buys a convertible bond and hedges it (in the same way as if the convert was priced at the theoretical value). At time t=½, the stock price falls to 95 and the convert price falls to 96.

a. Cheapness relative to theoretical value = 102.94 – 96 = 6.94.

b. P&L in dollars of the hedged convert position = -3.67, which is equal to the change in cheapness. The P&L is -3.63% of the initial price.

c. If the hedge fund can hold its position until time 1, the P&L from time ½ to time 1 will be 6.94. The total P&L over the two time periods will therefore be equal to -3.67+6.94=3.27, which is equal to the initial cheapness.

15.4 **Margin requirements.** After the hedge fund has marked-to-market its time-½ loss when the convert drops to 96, it has a net asset value of $100M. The hedge fund owns 4M convertible bonds. The hedge fund's prime broker states that the margin requirement for each convertible bond and its hedge is 30% of the convert value.

a. The margin requirement for the current position is $96*4M*0.30=$115.2M. The hedge fund does <u>not</u> have sufficient capital to meet the margin requirement.

b. The maximum position that the hedge fund can take is 3,472,222 bonds.

# *Efficiently Inefficient*

***How Smart Money Invests and Market Prices Are Determined***

## Solution to Exercises for *Event-Driven Investments*

### Volkswagen's Takeover of Scania

16.1 **Merger premium.** The price before the **announcement** was SEK 144.50 for the A shares and SEK 147.50 for the B shares. The offered price is SEK 200 for all share classes.

The "merger premium" is 200/144.5-1=38.4% and 200/147.5-1=35.6% for A and B shares, respectively. The merger premium is the difference between the pre-merger price and the offer, while the "deal spread" is the difference between the post-merger price and the offer. The announcement also computes the merger premium relative to the average prices over the past 90 and 30 calendar days, which can be viewed as a more robust measure in the sense that it is more difficult to manipulate a stock price for an extended time period than just one day.

16.2 **Merger event risk.**

a. Conditions for completion

- 90% shareholder acceptance
- Regulatory approval
- New legislation and regulation
- Circumstances with material adverse effect on Scania
- No materially incorrect information made public by Scania
- Scania not taking measures to impair the offer

These conditions are fairly standard. Most offers that fail do so because of lacking regulatory approval or lacking shareholder approval. The market for heavy trucks and busses is global and there are several players so, in this case, regulatory approval is to be expected. Given the high premium offered, shareholders are also likely to approve. Hence, one might expect the probability of the deal going through to be very high, say, 90-97% (this number comes with a lot of uncertainty).

It is reasonable to assume that the six conditions are independent so the completion probability is $P = \prod p_i$, where $p_i$ is the probability of condition $i$ being met or

waived. We see that each of these probabilities must be close to 1, perhaps about 99% on average.

b. If you worked for an event-driven investment manager and had more time and resources, you could work on your estimate of the completion probability. If you think the major risk is shareholder acceptance, you should find out who the major shareholders are and whether or not they are likely to accept the offer.

16.3 **Market-implied market risk.** To solve the problem, we assume that

- Scania trade will trade at SEK 145 if the merger is not completed, a price which is slightly below the pre-announcement price of Scania "B",
- there is a zero chance of completion at a price higher than SEK 200, and
- the risk-free return from announcement to completion is 0.

Given these assumptions, the implied risk-neutral completion probability *P* is given by

$$194.5 = 200P + 145(1 - P)$$

so $P = 90\%$.

16.4 **Mergers and share classes.** If the offer is completed then both share classes will have the same value. Given the high completion probability from above, the spread should be much smaller after the announcement (whatever the reason for the pre-announcement spread of 3 SEK was). With a 90% completing probability, the spread should be SEK 0.3. In fact, in reality it narrowed to SEK 0.1.

16.5 **Mergers and options.** The Black-Scholes formula assumes that stock prices evolve smoothly based on the Normal distribution (more precisely, a geometric Brownian motion), which is clearly not true for the Scania stock price. The Scania price is likely to jump at least when the resolution becomes known.

Resolution before September 19 is very likely, let's assume it is certain to happen. Then there is a 90% probability that the call is worth SEK 50 and 10% probability that it worth SEK 12 (the pre-announcement option price), i.e. the call should trade at approximately SEK 46.2.

You may get a different answer, but the option value should not be less than the intrinsic value (the stock price minus the strike price) of SEK 44.5 since the option is an American option. Also, the option value should be less than SEK 50 unless you assume that resolution may happen after September 19 or that completion may be at a higher price than SEK 200.

The put will only be valuable in case of failure and should have a value of about a tenth of its pre-merger value, i.e. approximately SEK 1.3.

Clearly, owners of a straddle (a call and a put) profited from the takeover announcement.

16.6 **Merger news.**

a. **Internal recommendation.** The recommendation is bad news and the share price should drop reflection an increased failure probability. In fact it dropped from 195.9 to 191.8.

b. If the recommendation had not affected the stock price, the natural interpretation is that this recommendation was expected by the market.

c. **Initial outcome of tender offer.** Volkswagen got 88.25% which is less than required, but so close that it is likely that they can get the 90% on board by extension of the offer period. This is an often seen situation and, if necessary, the acquirer often spends resources on contacting minor shareholders who may not have noticed the offer. In sum, this is good news and the price increased from 191.7 to 197.0 SEK.

16.7 **Merger outcome.** Now all certainty is removed and Scania is almost like a short-term zero-coupon bond. It closed at SEK 199.9.

16.8 **Negative deal spreads.** The most natural explanation of a negative deal spread is that there is a non-trivial probability that the offered price will increase either because of a competing bid or because the current acquirer needs to persuade more shareholders to accept the offer. A possible, though less likely, explanation is that the bid and associated merger discussions reveals new information about the value of the firm.

# *Efficiently Inefficient*

***How Smart Money Invests and Market Prices Are Determined***

## Solution to Exercises for *Event-Driven Investments*

### Trading on Carve-Outs

I thank the authors of the HBS case – Mark Mitchell, Todd Pulvino, and Erik Stafford – for their insights and the use of their material.

16.9 **Understanding carve-out trading.**

a. There can be many arguments related to the prospects of the businesses of Creative Computers and Ubid, but the pricing points toward buying CC is discussed further below.

b. Ubid has 9,146,883 shares of which 7,329,883 were held by Creative Computers post-IPO.

c. Creative Computers had 10,238,703 shares outstanding. Therefore, each Creative Computers share implicitly gave ownership of 0.7159 Ubid shares.

d. The value of the implicitly ownership in Ubid is 0.7159 × \$35.6875 = \$25.55, which is greater than the CC share price of \$22.75. Therefore, a natural long-short strategy is to go long Creative Computers and, for each long share in CC, short 0.7159 Ubid shares.

e. Most students who figure out the arbitrage trade decide to take a much too large position. Typically event-driven investors put at most 10% (or less) in a single trade, implying a maximum long position of \$2M.

16.10 **Balance sheet.** Creative Computers has a market capitalization of \$232.930M based on the share price \$22.75. The value of the stake in Ubid is \$261.585M based on the share price 35.6875\$. The balance sheet is in market value is:

| Creative Computer's Market Value Balance Sheet ($000s) | | | |
|---|---|---|---|
| **Assets** | | **Liabilities** | |
| Cash | 15,528 | Debt (all) | 3,152 |
| Net Working Capital | 6,737 | Stockholder's Equity (MV) | 232,930 |
| Property, Plant, Equipment | 15,040 | | |
| Other Long-Term Assets | 14,313 | | |
| Ubid Stake (approx 80.1%*) | 261,585 | | |
| Stub assets (Plug) | -77,121 | | |
| Total Assets | 236,082 | Total Liab & Equity | 236,082 |

The shocking finding is that the stub value is negative! Here, we have set property, plant, equipment and other long-term assets at their book values. This is not important for the main finding since the cash is above debt and the Ubid stake is worth more than the equity.

16.11 **Long-short stub trade.** Suppose Elena goes long 1 share of Creative Computers and short 0.7159 Ubid shares.

a. **Return on convergence.** The return on the strategy in dollars was

$$32.625 - 22.75 \; - \; 0.7159 \; \times \; (34 - 35.6875) = 11.08$$

The return as a percentage of the initial long position was 11.08/22.75=49%. The annualized return using compounding was 121%.

b. **Initial equity.** The initial margin equity on Dec. 9, 1998 for each share that SCM is long was $24.15.

c. and d. **Margin equity and margin requirements.** On Dec. 18, 21, 22, 23, the margin equity and margin requirements were as follows:

| | 9-Dec-98 | 18-Dec-98 | 21-Dec-98 | 22-Dec-98 | 23-Dec-98 |
|---|---|---|---|---|---|
| **CC share price** | $22.7500 | $28.8750 | $35.3750 | $46.9219 | $59.6875 |
| **Ubid share price** | $35.6875 | $53.1250 | $84.1250 | $134.5000 | $188.0000 |
| **Equity** | $24.15 | $17.79 | $2.10 | -$22.42 | -$47.95 |
| **Margin requirement** | $24.15 | $18.63 | $26.91 | $40.62 | $55.30 |
| **Margin shortfall** | $0.00 | $0.84 | $24.81 | $63.04 | $103.25 |

From December 18, the margin equity was insufficient to cover these margin requirements so additional cash had to be posted to cover the margin shortfall.

d. **Margin calls.** Suppose that you initially had taken a very large position of $2M in CC, i.e., 2M/22.75 = 87,912 shares. Correspondingly, you take a short position of 87,912 times 0.7159 shares, that is, short 62,936 Ubid shares.

Suppose that post your entire NAV of $20M on this margin account. Then your equity and margin requirement evolve as follows:

| | 9-Dec-98 | 18-Dec-98 | 21-Dec-98 | 22-Dec-98 | 23-Dec-98 |
|---|---|---|---|---|---|
| **Equity** | 20,000,000 | 19,441,011 | 18,061,417 | 15,906,116 | 13,661,279 |
| **Margin requirement** | 2,123,018 | 1,637,661 | 2,365,826 | 3,570,727 | 4,861,416 |
| **Free cash** | 17,876,982 | 17,803,350 | 15,695,591 | 12,335,389 | 8,799,863 |

Hence, you could sustain this position on all days under the assumption that you had no other positions (a very unrealistic assumption).

Must students take much larger positions and it is important to discuss why such positions are too large ex ante (i.e., even before you know how poorly things turn out).

Consider how painful the $2M position is on December 23. You have lost more than $6M on a single position! Said differently, a single position means that the hedge fund is down 32%. Further, the limited free cash of $8.8M means that you can take few other positions. This stub trade has become a nightmare and a way too large proportion of your hedge fund.

Most students take even larger positions which mean that they go broke (their equity becomes zero or at least too little to meet the margin requirement). They feel that this was just bad luck and clients should just give them more equity so that they can ride the trade until convergence. In reality, clients are very unlikely to do so because such a large position may be taken to reflect such problems as:

- Poor position sizing – why did you size a single trade so large?
- Did you not have any other trading ideas and therefore put everything into one trade?
- Poor risk management – why didn't you reduce the position when things turned south?
- Didn't you realize that when the market can initially offer a negative stub value, it can become even more negative as well?
- On December 23, you and your clients may even question the initial trading idea – was it even an arbitrage to begin with…?