20.12.2016

NORGES HANDELSHØYSKOLE

Term Paper

Pairs Trading and the impact of a merger

Trading and Market Microstructure

Theodora Koutsothanasi (s156320)
Markus Klaus (s156322)
Matty Wiener (s156263)

Table of contents

1. Introduction in Pairs Trading 2

1.1 Abstract and definition 2

1.2 Statistical arbitrage and risk arbitrage 2

1.3 The Merger of Pfizer Inc and Allergan PLC 3

2. Applying Conventional Pairs Trading 4

2.1 Basics and backtesting 4

2.2 Run the conventional pairs trading from 2004 - 2016 7

3. The Adjusted Pairs Trading Strategy 9

3.1 Adjustments of the conventional strategy 9

3.2 Run the adjusted pairs trading from 2004 - 2016 10

3.3 Further adjustment 12

4. Applying Risk Arbitrage 14

5. Potential Financial Instruments 17

6. Conclusion 18

7. List of Literatures 19

1. Introduction in Pairs Trading

1.1 Abstract and definition

Pairs trading is one of many profitable trading strategies which exist in the stock market. In our term paper we examine the statistical and the risk arbitrage opportunity. At the beginning conventional pairs trading is very profitable. But as we will see, we will come to a point where it is not possible anymore to follow this strategy. Thus we will implement a modified strategy which withstand unexpected occurrences – like the impact of a merger and other fundamental changes between the two stocks. Indeed, this strategy will generate on the one hand a lower profit and is also riskier but can always be continued without a big research effort. Since the profit is too small in total of the modified method we will improve this modified strategy by a measure which execute orders faster and leads to an improvement of $18,26 at the end. At the end we will also show possibilities how to realize pairs trading with financial products.

In the middle of 1980s, pairs trading was part of the creation of a profitable activity at Wall street. Pairs trading is a neutral strategy that in the same time buys a security, and sells another similar. (Andrade, et al., 2005).There are two kinds of pairs trading in the equity of markets; statistical arbitrage pairs and risk arbitrage pairs. (Vidyamurthy, 2004 pp. 8-9)

1.2 Statistical arbitrage and risk arbitrage

Statistical Arbitrage is tracking a pair of securities whose prices move together. When prices diverge, traders buy (long position) the underpriced stock, and simultaneously take a short position against the overpriced security. If the trader does not take into account common valuation factors, the prices will diverge. (Harris, 2003 p. 360) Traders hope that the prices will converge, gaining from the right position they chose. On the contrary, if prices diverge further, traders lose. (Vidyamurthy, 2004 pp. 8-9)

Statistical arbitrageurs detect the factors or use statistical methods to find which aspects regulate the prices. Some of those features are macroeconomic variables (interest rate, industrial production, credit spreads, market volatility). The statistical methods that traders use are factor models, canonical correlation and principal components. Both specific features and statistical methods help to define which security is overpriced or underpriced, helping to the actualization of pairs trading. (Harris, 2003 p. 360).

Risk arbitrage is another type of pairs trading, which is referred to arbitrage that involves firms that will be merged or acquired. In this situation, the acquiring firm (bidder) acquires a target firm. The merger can be achieved by cash or by stock exchange. In both situations, the bidder

usually pays a premium above the price of the target firm. Traders speculate that a premium is paid, because they take a long position for the acquired firm and a short position for the bidder. If the merger is achieved, traders will gain the premium from the acquired firm. Thus, it is very certain that the price of the bidder will fall, due to the extra price that paid for the merger. As the name suggests, at risk arbitrage strategy the profits are uncertain, because with this strategy are also big losses possible. Traders speculate that the merger will not fail. If the merger succeeded, the trader, who bets on the merger will gain more money than he will lose. (Harris, 2003 p. 360)

As we wanted to analyze both strategic and risk arbitrage, we thought that this is the best pair for this paper. During the time there were some opportunities for strategic arbitrage. Consequently, we will check if the risk arbitrage strategy is profitable enough for this example.

In the following we will try to develop the above-mentioned methods of pairs trading for Pfizer and Allergan. Although Pfizer and Allergan is not a perfect pair, we wanted to test how good these strategies function if everything is not going well. An unexpected development at the stock market is what happens very often: The future is uncertain and every day there are unpredicted news which can destroy too inflexible strategies. We will analyze the flexibility of the pairs trading strategy based on the performance and adaptability.

1.3 The Merger of Pfizer Inc. and Allergan PLC

In the end of 2015 it was announced that these two companies will merge, which means that this announcement will probably open an opportunity for traders to do risk arbitrage. On the 23rd of November 2015 the Pfizer and Allergan merge was announced. If these pharmaceutical companies merged, the world's biggest drug company by sales would be created. (Smith, Groden, 2015).

The main reason why Pfizer wanted to buy Allergan was due to the reduction of tax bills by moving its domicile out of the U.S. to Ireland - Allergan's place of business. The merger would help Pfizer to avoid American corporate taxes and reduce the tax rate from 25% to 17%-18%. But to make this happen Allergan PLC – the smaller company of both – had to merge Pfizer Inc. in order to shift the place from the U.S. to Ireland. In practice, however, Pfizer would hold more than 50% of shares in the new company and continues to be the leader. The new firm would be named as Pfizer PLC and continues to be led by Chief Executive Officer Ian Read from Pfizer.

The merger deal would be worth $160 billion and would take place in a stock transaction, valued at $363.63 per Allergan share, based on the closing price of Pfizer common stock

of $32.18 (November 20, 2015). The premium for this transaction is more than 30 percent, according to the share prices of Pfizer and Allergan (October 28, 2015). For each share that Allergan shareholders have, they would receive 11.3 shares of the combined company. As published on the web page from Allergan (Allergan, 2015) Pfizer shareholders would receive in a ratio of 1-1 shares of the combined company for each of their Pfizer shares.

Nevertheless, the U.S. did not support the idea of the merger, as it would lose earnings from taxes and many people would be jobless. On the 6th of April 2016, the U.S. government introduced new rules, in order to keep companies from doing inversion deals. Hence, the processes for the Pfizer-Allergan merger was terminated. Pfizer was obligated to pay Allergan a $150 million fee, as a reparation for the merger termination. (DiChristopher, Faber, 2016)

To sum up, this was the chronicle for the merger. In the beginning the news was very optimistic about the merger. Investors could gain a lot of money, because of the huge premium. However, such a big premium and the claim of many politicians that this merger should not take place were indications that the merger will fail. Finally, the deal failed.

2. Applying Conventional Pairs Trading

2.1 Basics and backtesting

The used data is provided from Yahoo Finance. Both stocks are listed in the New York Stock Exchange (NYSE) and are traded in US Dollar (USD). For each company, data were available from February 1993 until this day. We decided to use data starting from the 1st of January 1999 till the recent days to examine the data from the firms and run the 'Backtesting'. This latter will be later explained in this essay.

The downloaded file with data about both firms also contains adjusted prices of a stock besides the conventional information like dates, open and closing prices. This is beneficial because adjusted prices provide prices without impacts of dividends or equity splitting. The only adjusted prices at Yahoo Finance are the adjusted close prices.

Applying our task, we tried to figure out if our choice of companies was good by calculating the correlation between both firms and whether we can choose a day which represents a good relation of the two stock prices.

By running the calculations of correlation for different time periods with Excel, e.g. for 60 or 200 days of observation from 2002 to 2009, we were confronted with a huge volatility as shown in figure 1 and 2.

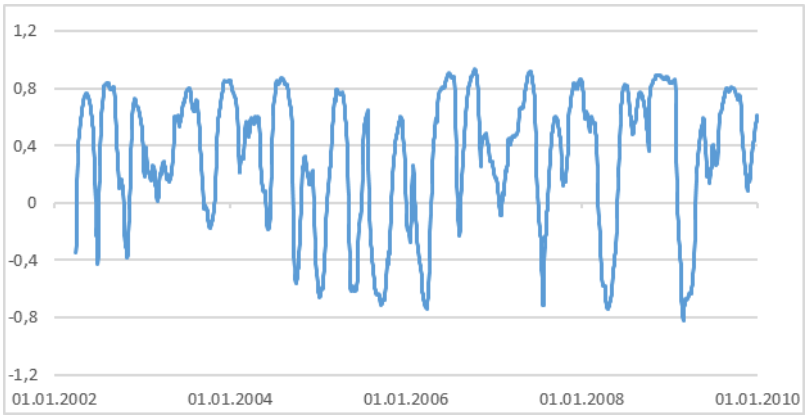


Figure 1 - 60-days correlation

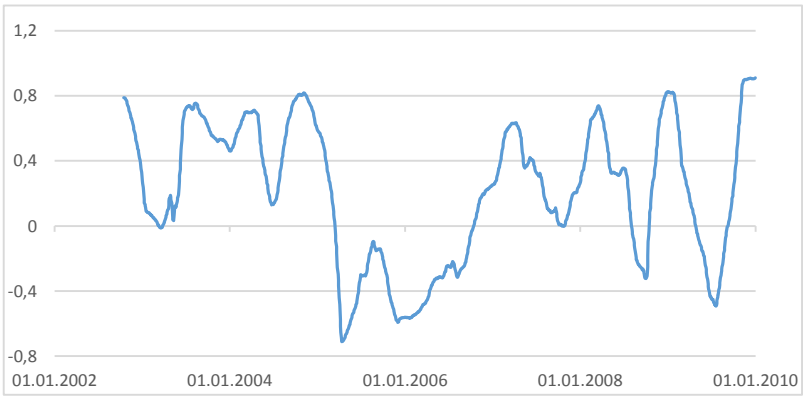


Figure 2 - 200-days correlation

As seen above, under observation of 60 and 200 days of data, the correlation is highly volatile and sometimes even negative. When you try to find a relative fair value to enable pairs trading, the correlation needs to be positive and preferably close to 1. In this case correlation is not useful to set a specific date in which the relative fair value between both stock prices could be computed. Because choosing a representative date for a relative fair value would cause a wrong ratio between both stock prices and might lead to reject the company choices. Thus, another possibility for verification was needed.

The method we tried next, was the backtesting with past ratios of the two stocks. 'Backtesting' is a common financial process of testing to ensure the feasibility of pairs trading. Backtesting itself is defined as "creating a hypothetical portfolio performance history by applying current asset selection criteria to prior time periods" (Nasdaq, 2016). Our chosen backtesting period was from the 1st of January 1999 to the 31st of December 2003. To prove if pairs trading can work after this period, we computed the daily ratio between the stock prices by dividing Pfizer Inc. through Allergan PLC and plotted the results into a graph as shown in figure 3. Furthermore, we draw a trend line over this time which indicates the general pattern of the time

series data. As it can be seen, the relative fair value is approximately 0,6 over this time and can be determined for the following pairs trading strategy starting in 2004.

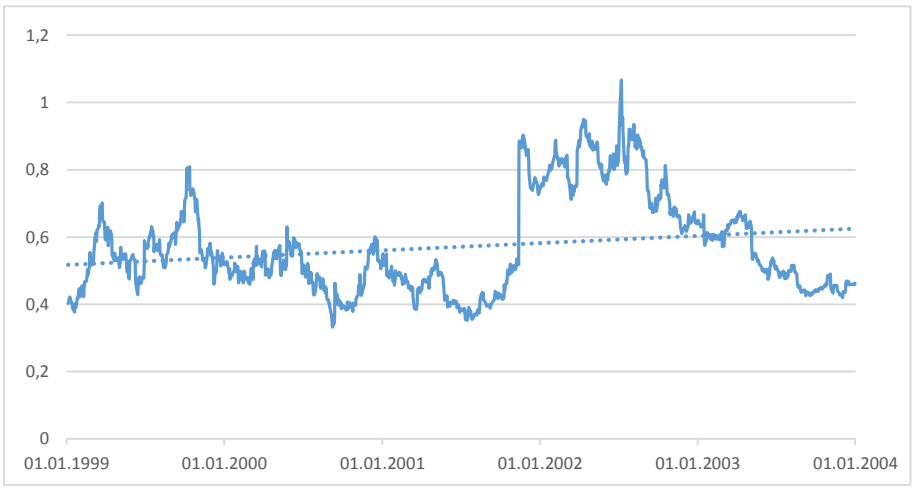


Figure 3 - Backtesting: ratio between Pfizer/Allergan in absolute numbers

Moreover, the backtesting on this historical prices should show if a trading strategy is working. Based on this pre-investigation a trader decides if his trading strategy is worth to put it into practice. And our pairs trading strategy can be described as the following: Whenever the ratio between both companies is reaching 120% of the initial fair value (in our case: 0,72), we sell the hedged portfolio Pfizer/Allergan. When it is reaching 80% (in our case: 0,48) we buy the hedged portfolio, and if it returns to 0,6 – the initial relative fair value of 100% – we closed our positions. Examining figure 4 below, during the observed time period from January 1999 to December 2003 there are four moments where buying the portfolio (red circles) and two times of selling it (green circles) were possible. So in total six points in time where pairs trading could be done. We decided to start with pairs trading from the 2nd of January in 2004.



Figure 4 - Backtesting: ratio between Pfizer/Allergan in percent (0,6 = 100%)

But first, before every trader puts the strategy into practice, risk limits should be defined. Risk bounds in our pairs trading strategy are reached whenever the ratio is fallen from 100% to 60% or rising to 140% - 0,36 and 0,84 in absolute numbers. In this situations losses are cut by closing the positions and avoid higher impending losings. We chose these risk limits because of the same distance (20 percentage points) to the 'opening position point' (80% or 120%) like the normal 'closing position point' (100%).

2.2 Run the conventional pairs trading from 2004 - 2016

Hence, pairs trading can be applied using the described strategy. Over the time from 2004 to the recent days, several possibilities are given to take long and short positions. Observing the trading period starting in 2004, the following graph (figure 5) shows the possible moments whenever the trades are positioned.

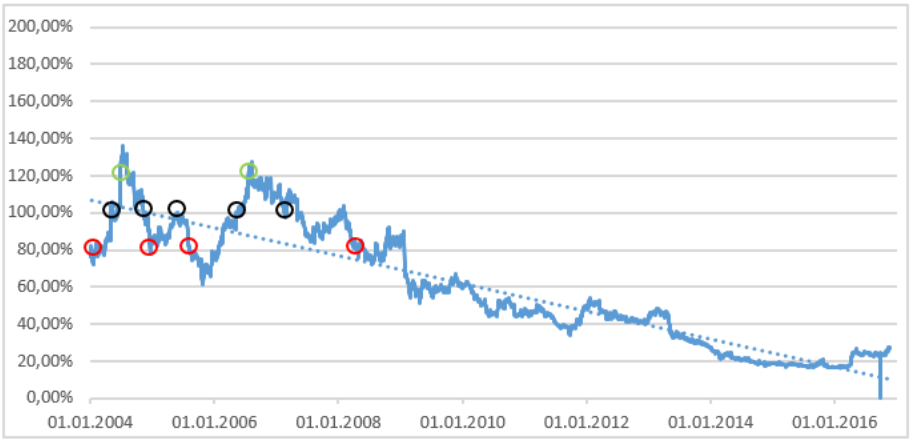


Figure 5 - ratio Pfizer/Allergan (0,6 = 100%)

According to the main strategy of pairs trading, we bought the hedged portfolio low and sold it high. In total there were four times to buy the hedged Pfizer/Allergan portfolio (red circles) and two times to sell the hedged portfolio (green circles). The black circles stand for the settlement of the taken positions before. After five years of trading the profit and loss per trade is given in the table below (figure 6). Here are the red marked lines the buy-, and the green ones the sell-situations, aligned with the circles in figure 5. At the first appearance, our strategy succeeded and generated a profit of $28,32. The pairs trading portfolio has a correlation with the Dow Jones of 18.4%, a relatively low correlation to the market. This means that this strategy can also generate profits if the market goes down (e.g. significant drop downs at the stock market).

	Position Pfizer/Allergan	Pfizer	Allergan	Sum
02.01.2004	Buy/Sell	-21,40	21,40	0,00
30.03.2004	Sell/Buy	45,81	-35,61	10,20
28.06.2004	Sell/Buy	27,49	-27,49	0,00
10.11.2004	Buy/Sell	-22,42	28,51	6,09
20.12.2004	Buy/Sell	-31,99	31,99	0,00
24.05.2005	Sell/Buy	38,53	-30,10	8,43
08.08.2005	Buy/Sell	-34,09	34,09	0,00
10.05.2006	Sell/Buy	33,71	-26,95	6,76
21.07.2006	Sell/Buy	21,42	-21,42	0,00
20.02.2007	Buy/Sell	-24,32	29,19	4,87
17.04.2008	Buy/Sell	-29,51	29,51	0,00
19.02.2009	Sell/Buy (Stop Loss)	21,78	-29,81	-8,03
				28,32

Figure 6 – order book with profit and loss during the time

But by taking a closer look at the last trade and the first involved loss afterwards with this strategy, something might have gone wrong. Also in figure 5 this crucial point in time can be observed. This graph and the displayed trend line of the ratio Pfizer/Allergan from 2004 until now shows a dropping relation over the entire trading period. By comparing the relative ratios over time the 19th of February in 2009 is the first day and the mentioned crucial point in time when the ratio broke through the risk bound of 60% and keeps falling afterwards. Orders before this date were exercised by the trader himself. When the border is reached, the Stop Loss order – which should be used to react fast when something unobserved happens and to avoid too high losses - is activated and taken positions are closed.



Figure 7 - portfolio value during the time

Our portfolio value over the trading session also represents the loss with the last trade due to the broken risk limits and the time without any possible trade after. This is clarified in figure 7 with the dropping red arrow and the subsequently flat value line.

This implies that using this kind of trading strategy is no more working after this particular moment. From this time on, the ratio is not revealing to the fair value again. The amount of possible trading positions and also the profit at the end are related with how good the fair value was calculated or estimated at the beginning. Regarding this influential moment at the 19th of February in 2009, the trading strategy should be reconsidered and new aligned.

3. The Adjusted Pairs Trading Strategy

3.1 Adjustments of the conventional strategy

Like above was shown, it can be seen that unexpected happenings like a merger can change the fair ratio between two companies fundamentally. The fair ratio can also change because of performance differences. If one company permanently earns more money than the other one this also leads to a slow but steady change in the fair value. Hence, to be successful on long term with the pairs trading there is a necessity of adjust continuously the fair value.

Regarding the possible merger and the following contrary price development of the two companies we developed an alternative way to profit from the price movements of Pfizer and Allergan. Since there is a big trend to a low ratio of Pfizer/Allergan, we have to modify the fair value of the ratio. Our idea is to reach this by using a moving average of past ratios, instead of normalizing one ratio to 100%, as we did it before with 0,6 ≙ 100%. The Question is how many data from the past the floating average should comprise. The longer it goes into the past the less current significant trends affect the fair ratio but also the more resilient against outliers it gets. It is important that the period is not chosen too short, because otherwise there are not enough signals that the ratio between the two stocks is over- or underpriced.

Another difference to the conventional pairs trading are the risk limits. We are of the opinion that it is not necessary to close direct a position if the percent value reaches a certain value (like in the first part 60% and 140%). The advantage of the moving average is that it adjusts itself for new fair values. So if the ratio value is a longer time on a higher or lower level this leads automatically to an adaption. As a consequence, the 100% will be reached faster again than in the conventional pairs trading strategy - especially if we take a shorter period for the moving average.

Except from the different normalized value of the Pfizer/Allergan ratio and the unnecessity of the risk bounds this strategy is realized quite similar to the conventional pairs trading.

This modified strategy also has a big disadvantage: It is not guaranteed, that with every trade (e.g. from 80% fair value to 100% fair value or from 120% f.v. to 100% f.v.) this strategy makes a profit like the conventional strategy. The reason for this is the changing fair value: The longer a position is hold, the riskier this profit will be, because the "100% ratio" of the two stocks can be totally different at the opening and the closing point in time. This is the reason why the portfolio value can also be negative.

3.2 Run the adjusted pairs trading from 2004 - 2016

Realizing this strategy with a moving average for the fair value for the past 60 trading days, which are about three months, the ratio of Pfizer/Allergan can be seen in figure 8.

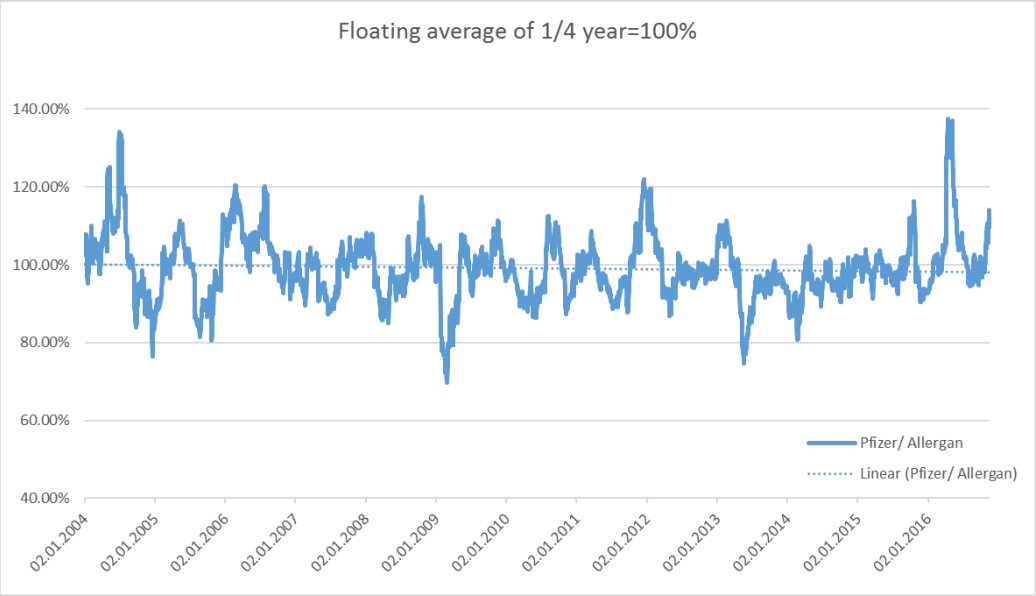


Figure 8 – fair value with floating average

The pointed blue horizontal line is again the trend from the ratio. As it can be seen the downward sloping trend of figure 5 is almost completely removed through the floating average. Whenever the fair ratio value reached 80% we took the long position (Buy/Sell). We closed the position like in the conventional pairs trading strategy at 100% and took the short position (Sell/Buy) whenever the value reached 120%. After 12,5 years of trading the trading history can be seen below.

	Position Pfizer/Allergan	Pfizer	Allergan	Sum	Days position was hold
11.05.2004	Sell/Buy	35,30	-35,30	0,00	
16.08.2004	Buy/Sell	-31,17	27,67	-3,50	97
17.12.2004	Buy/Sell	-31,95	31,95	0,00	
08.02.2005	Sell/Buy	31,69	-28,92	2,77	53
24.10.2005	Buy/Sell	-35,85	35,85	0,00	
13.12.2005	Sell/Buy	38,26	-33,10	5,16	50
21.02.2006	Sell/Buy	29,83	-29,83	0,00	
01.05.2006	Buy/Sell	-29,21	29,02	-0,19	69
24.07.2006	Sell/Buy	21,63	-21,63	0,00	
15.09.2006	Buy/Sell	-24,70	27,07	2,37	53
02.02.2009	Buy/Sell	-27,16	27,16	0,00	
05.05.2009	Sell/Buy	26,61	-30,03	-3,42	92
13.12.2011	Sell/Buy	60,57	-60,57	0,00	
21.03.2012	Buy/Sell	-64,19	63,69	-0,50	99
13.05.2013	Buy/Sell	-120,52	120,52	0,00	
22.10.2013	Sell/Buy	126,91	-146,89	-19,98	162
20.02.2014	Buy/Sell	-220,37	220,37	0,00	
04.04.2014	Sell/Buy	224,68	-201,31	23,37	43
13.05.2016	Sell/Buy	223,35	-223,35	0,00	
20.07.2016	Buy/Sell	-246,86	246,95	0,09	68
				6,17	

Figure 9 – order book (modified strategy)

From 2004 until the third quarter of 2016 we made 20 trades (10 times opening position, 10 times closing position). Compared to the conventional pairs trading the number of trades also increased because this strategy can also be continued if the fair value significantly changes between the two companies. From these 10 positions, we made 5 times a profit and 5 times a loss, whereby two times the loss was close to 0. We always traded one stock of Allergan and x stocks of Pfizer, where

$$x = \frac{\text{Price during opening position of Allergan}}{\text{Price during opening position of Pfizer}}.$$

So we constructed the same basics like in the conventional pairs trading. In total the strategy generated $6,17 profit (regardless of transaction costs). The process of the portfolio value can be seen in the following chart.

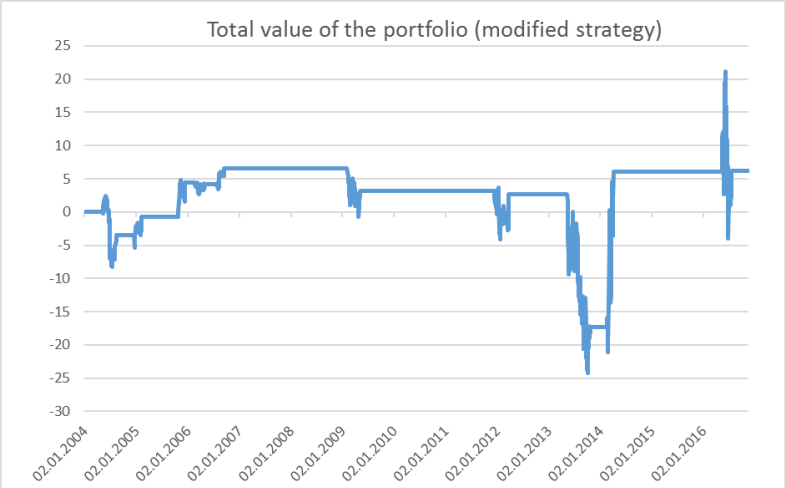


Figure 10 - total value of the portfolio (modified strategy)

Especially the huge drop during 2013 shows that this strategy is riskier than the conventional pairs trading. If there was not the profit with +23$ direct after the drop, this strategy would end 2016 in a minus value. We also observe that this strategy did not always choose the perfect moment to close a position. Especially the big spike during 2016 shows that this strategy could have made a total profit of over $20, if we closed our last position earlier.

In total this portfolio has a correlation with the Dow Jones Index (Pfizer is part of the Dow Jones) of 0.048. This means it is nearly independent from the market. Also the correlation to Pfizer and Allergan with -0,08 and 0,06, respectively, are very close to the 0.

Having a look at the days the position was hold and the profit of this single position, it seems like the longer the position is hold the more likely a loss is engendered. This hypothesis is supported by the following regression we generated.

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	20,43405852	4,684341077	4,3622055	0,00240551
Days position was hold	-0,252125426	0,054724955	-4,607138	0,00173915

Figure 11 - regression

The results of this regression show, that in average every day of holding the position longer decreases the profit significantly (p-value < 1%) by $0,25. This means for example that the average profit for a position which was hold 10 or respectively 100 days is:

$$\emptyset\, profit\ (10\ days) = \$20{,}43 - 10 * \$0{,}25 = \$17{,}93$$

$$\emptyset\, profit\ (100\ days) = \$20{,}43 - 100 * \$0{,}25 = \$ - 4{,}57$$

One way to make this strategy less risky would be a temporal risk limit which closes the position after a certain number of days instead of depending on the current ratio between the two stocks like in the conventional pairs trading strategy.

Compared to the conventional pairs trading this new strategy generates a definite lower profit. The fact that the profit of each closing position is uncertain makes this strategy also riskier than the conventional pairs trading. The advantage is that this strategy is the automatically adjustment, so that the trading can always be continued without a big research effort, because the fair value builds itself with new data.

3.3 Further adjustment

The essential point is that the positions should be hold shorter in this modified strategy, so that the likelihood of a profit is increased. A static temporal risk limit (e.g. close position after 50

days) is not very effective, since the positions might be closed at a bad point in time, when the ratio of Pfizer/Allergan is unfavorable. That is the reason why we increased the "closing position range". Before, we only closed the position when the ratio reached approximately 100% (99,5%-100,5%). We increased this range to 90%-110%. Through this method, the positions are closed faster which increases the likelihood of a profit. It also leads to smaller profits because the difference, which is gained is now only 10 percentage points (120%-110% or 90%-80%) instead of 20 percentage points. As in the order book in figure 12 can be seen, the number of positions increased from 10 to 12 (new positions are marked blue) and the average holding period decreased clearly from 78 days to 27 days.

	Position Pfize	Pfizer	Allergan	Sum	Days position was hold
11.05.2004	Sell/Buy	35,30	-35,30	0,00	
26.05.2004	Buy/Sell	-34,45	36,90	2,45	15
15.07.2004	Sell/Buy	26,30	-26,30	0,00	
03.08.2004	Buy/Sell	-26,19	26,97	0,78	19
17.12.2004	Buy/Sell	-31,95	31,95	0,00	
11.01.2005	Sell/Buy	32,43	-30,65	1,78	25
24.10.2005	Buy/Sell	-35,85	35,85	0,00	
03.11.2005	Sell/Buy	37,18	-32,89	4,29	10
21.02.2006	Sell/Buy	29,83	-29,83	0,00	
29.03.2006	Buy/Sell	-29,36	28,77	-0,59	36
24.07.2006	Sell/Buy	21,63	-21,63	0,00	
09.08.2006	Buy/Sell	-23,04	23,85	0,81	16
30.01.2009	Buy/Sell	-27,28	27,28	0,00	
15.04.2009	Sell/Buy	26,49	-29,65	-3,16	75
13.12.2011	Sell/Buy	60,57	-60,57	0,00	
10.01.2012	Buy/Sell	-64,01	64,58	0,57	28
17.01.2012	Sell/Buy	57,98	-57,98	0,00	
27.01.2012	Buy/Sell	-56,78	59,74	2,96	10
13.05.2013	Buy/Sell	-120,52	120,52	0,00	
10.07.2013	Sell/Buy	116,68	-124,07	-7,39	58
20.02.2014	Buy/Sell	-220,37	220,37	0,00	
07.03.2014	Sell/Buy	226,52	-213,18	13,34	15
13.05.2016	Sell/Buy	223,35	-223,35	0,00	
01.06.2016	Buy/Sell	-233,84	242,40	8,56	19
				24,40	

Figure 12 - order book with further adjustment

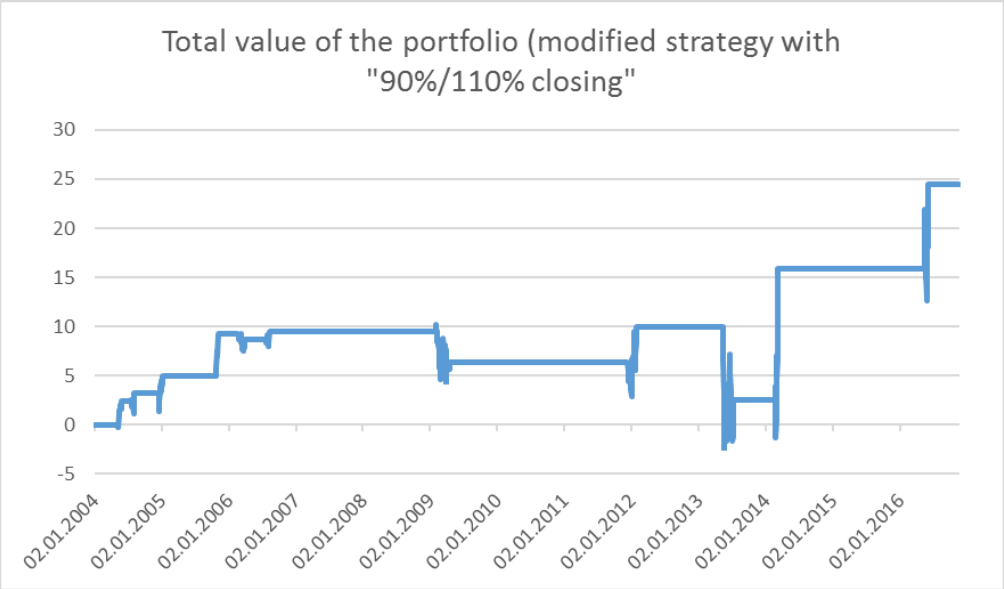


Figure 13 - total value of the portfolio with further adjustment

As visible in Figure 13 the performance of this further adjustment is better than before (Figure 10). This change leads to a performance from 2004 until 2016 (third quarter) of $24,43. Which is an improvement of $18,26. On top of this performance increase, the loss during 2013 is reduced drastically.

All in all, the performance of the modified strategy (from 3.1 and 3.2) is too small if we also include the transaction costs and fees which are charged by brokers, banks and exchanges to replicate the above portfolio with financial instruments. With the further adjustment in 3.3, the strategy is improved, so that the profit should exceed the transaction costs. Although it is still less profitable than the conventional pairs trading, we also have to consider that this strategy was also used during more difficult times (e.g. the financial crisis and the merger). On top this strategy can still be used for the future without adjustments while the conventional strategy has to be back tested again.

4. Applying Risk Arbitrage

Assuming that a trader wants to apply the risk arbitrage strategy at the day when the merger was announced. Technically, it seems that Allergan wanted to merge Pfizer. However, in reality Pfizer wanted to acquire Allergan for $160 billion. Pfizer shareholders would hold 56% of the stocks and the shareholders from Allergan 44%. As a consequence, the trader should buy stocks of Allergan and take a short position for Pfizer. He is expecting that the merger will be achieved, and he will gain the premium price from the merger. Thus, he thinks that the price of Pfizer stocks will fall, because Pfizer paid a greater price per Allergan share than it is actually worth.

According to Eccles, et al. (1999)'s survey of Harvard Business Review, very low or very high acquisition premium, leads to merger failures. The premium of this offer was greater than in other comparable merger situations, which means that the risk was high. On top of this there was a high possibility that the merger would not be achieved, due to political regulations.

The risk arbitrageur has mainly three sources of profit. First, if the merger is successful, he can sell his securities for the premium price. Second, he will receive dividend from the merged firm. At least, he will probably earn profit from the short position he took against the acquiring firm.

The following graph presents the arbitrage spread for the stock of Allergan during a certain period of time (date of merger's announcement until termination date). The arbitrage spread is defined as the offer price minus the target price divided by the target price. (Mitchell, Pulvino, 2001)

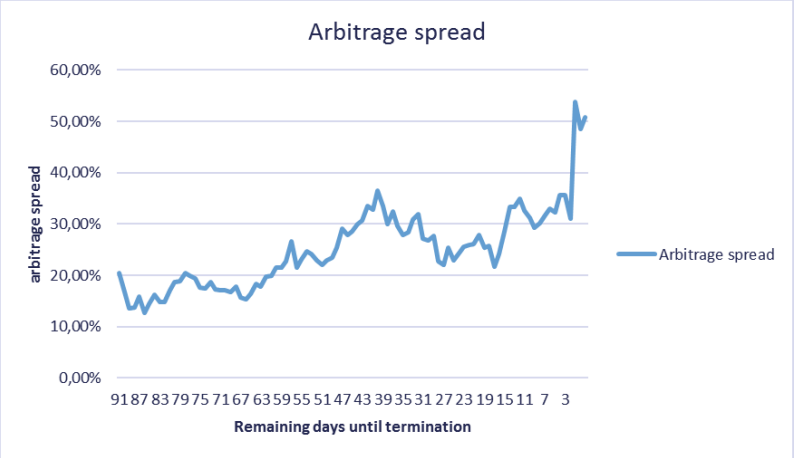


Figure 14 - arbitrage spread

It is observed that the arbitrage spread is very high and volatile during the time. Consequently, the arbitrage spread implicates that the merger deal can possibly fail. The day the merger was terminated, the arbitrage spread raised more than 25%, causing tremendous losses for the arbitrageur. If the merger was more likely to be successful, the line in the graph would tend to zero. Hence, trader could take the premium price.

Buying stocks of Allergan caused losses. The trader bought the stocks on 23rd of November at a price of $301,72 per share. The value of the stock of 6th of April was $241. This fall of the prices caused tremendous losses. For a duration of 91 days, the trader lost {(301,72-241)/301,72} =20,125% of the value of his money. The annual loss is calculated by the formula:

$$r\ annual = (1 + rperiod)^{No\ of\ periods} - 1 = (1 - 20{,}125\%)^{\frac{91}{365}} - 1 = -5{,}125\%$$

In total, the trader lost 20,125% of his money.

The following graph shows the return's configuration from 23rd of November 2015 until 6th of April 2016. Returns were very volatile during those months, because the development of the merger depended on the news. Good or bad news for the merger deal moved the stock prices of Pfizer and Allergan, accordingly.

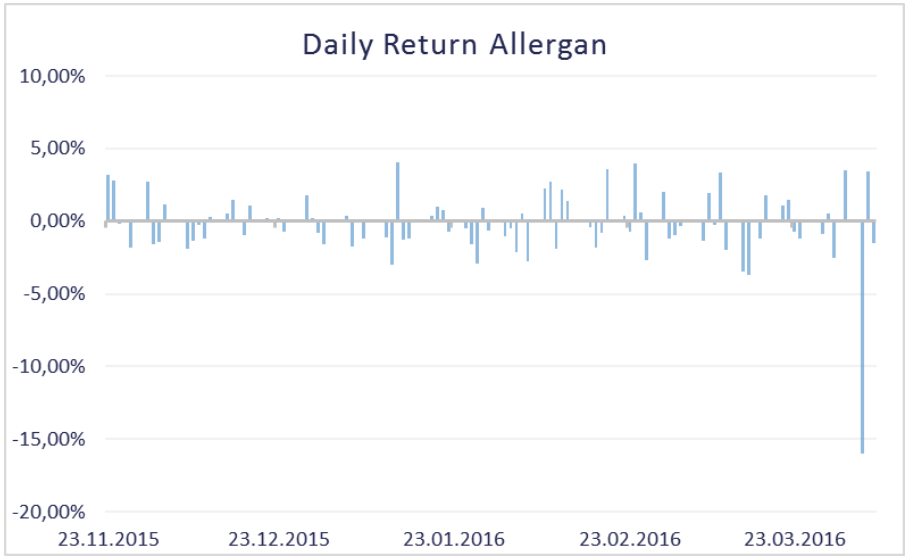


Figure 15 - daily return Allergan

Additionally, there is a loss in the short position of Pfizer. Although the trader first gains money (stock decreases in the first months), he loses by the short position, that he took at the 23rd of November 2015 in Pfizer stock, in total because the stock price increased at March 2016 up to 32.



Figure 16 - stock price Pfizer

5. Potential Financial Instruments

For realizing the strategies above (conventional pairs trading or modified method) different financial instruments are existing.

One possibility would be using CFDs ("Contract for difference"). CFDs are offered by a CFD broker and are relative simple structured. Instead of really buying or selling the underlying asset, it is just a contract which is made with the broker. The trader has only two different possibilities: Go long if you think the prices go up or short if you think the prices go down in the underlying asset. When the position is opened, no money has to be paid (regardless transaction costs), but the trader normally has to make a deposit. This guarantees the broker that he will get the money in case of a loss of the trader. When the position is closed, the difference between the old and new price will be transferred from the trader who made the loss to the one who made the profit.

Other products to simulate the cash flows above are put and call options. With them the trader bets on falling or increasing prices, respectively. A call option gives the buyer the right, but not the obligation, to buy the underlying asset for a specific price. A put option gives the buyer the right, but not the obligation, to sell the underlying asset for a specific price. To buy options the buyer has to pay an option premium. Unfortunately, we only found historical option prices for Pfizer and not for Allergan, so that we could not replicate now the exact portfolio with options. But in general it would function like the following: If the ratio is at 120% we want to sell Pfizer and buy Allergan. So we buy call options of Allergan with a strike price near to the actual price (at-the-money call). Additional to the call options we buy put options on Pfizer (also with a strike price near to the actual price). To calculate how many put options we need, we also took the formula from above:

$$x = \frac{\text{Price during opening position of Allergan}}{\text{Price during opening position of Pfizer}}.$$

The options should all have a relatively long maturity. The first reason for the long maturity is that otherwise the time value of the options falsifies too much our results (option lose value with every day of holding it). The second reason is that we do not know how long we have to hold the position. Hence, the option could reach its expiry date before we want to close our position. When we want to close our position, it is normally the best to sell the options at an exchange, since the options have still a time value. On top of this an earlier exercise is only possible with American options but not with European ones.

6. Conclusion

To come to a conclusion, also if there is a possible merger and other unexpected news, there are still strategies (risk arbitrage or the conventional pairs trading strategy) to earn money with these companies. There are two different cases. In case of regular news, the most important thing for the performance of those strategies are reliable information and a good setup (or backtesting) to lead the own individual strategy to a success. In case of unexpected big news especially the risk limits are essentially. This prevented for example bigger losses in the conventional pairs trading. We were surprised that in total the conventional strategy worked way better than our modified strategy, but with the further adjustment which is similar to a temporal risk limit (positions are closed faster) this would also make the modified strategy successful enough to bet the market. On top of the good performance this method is flexible enough to adapt itself to unexpected big news like the merger.

7. List of Literatures

Allergan. 2015. *Pfizer and Allergan to combine.* Retrieved December 19, 2016, from http://www.allergan.com/news/news/thomson-reuters/pfizer-and-allergan-to-combine.

Andrade, Sandro C., di Pietro, Vadim and Seasholes, Mark S.. 2005. *Understanding the Profitability of Pairs Trading.* Unpublished working paper, UC Berkeley, Northwestern University. p. 2.

DiChristopher, Tom and Faber, David. 2016. *Allergan CEO: Merger with Pfizer was targeted by US government.* Retrieved December 19, 2016, from http://www.cnbc.com/2016/04/05/pfizer-allergan-will-mutually-terminate-merger-over-inversion-rule-changes-sources-say.html.

Eccles, Kersten L., Lanes, Thomas C. and Wilson, Robe. 1999. *Are You Paying Too Much for That Acquisition?.* Retrieved December 19, 2016, from https://hbr.org/1999/07/are-you-paying-too-much-for-that-acquisition.

Harris, Larry. 2003. *Trading and exchanges. Market Microstructure for Practitioners.* New York: Oxford University Press. 0-19-514470-8.

Mitchell, Mark and Pulvino, Todd. 2001. *Characteristics of Risk and Return in Risk Arbitrage.* s.l. : The Journal of Finance, 56(6) p. 4.

Nasdaq. 2016. *Back-testing.* Retrieved December 19, 2016, from http://www.nasdaq.com/investing/glossary/b/back-testing.

Pierson, Randsell and Berkrot, Bill. 2015. *Pfizer to buy Allergan in $160 billion deal.* Retrieved December 19, 2016, from http://www.reuters.com/article/us-allergan-m-a-pfizer-idUSKBN0TB0UT20151124.

Smith, Geoffrey and Groden, Claire. 2015. *Pfizer, Allergan Confirm $160 Billion Merger Deal.* Retrieved December 19, 2016, from http://fortune.com/2015/11/23/pfizer-allergan-merger/.

Vidyamurthy, Ganapathy. 2004. *Pairs trading - Quantitative methods and analysis.* New Jersey: Wiley Finance. 0-471-46067-2.