Operations Research Proceedings 2008

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Editors

Operations Research Proceedings 2008

Selected Papers of the Annual International Conference of the German Operations Research Society (GOR) University of Augsburg, September 3–5, 2008

Springer

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ISBN 978-3-642-00141-3 e-ISBN 978-3-642-00142-0
DOI 10.1007/978-3-642-00142-0
Springer Dordrecht Heidelberg London New York

Library of Congress Control Number: 2009926697

Cover design: WMXDesign GmbH, Heidelberg, Germany

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

The international conference "Operations Research 2008", the annual meeting of the German Operations Research Society (GOR), was held at the University of Augsburg on September 3-5, 2008. About 580 participants from more than 30 countries presented and listened to nearly 400 talks on a broad range of Operations Research.

The general subject "Operations Research and Global Business" stresses the important role of Operations Research in improving decisions in the increasingly complex business processes in a global environment. The plenary speakers Morris A. Cohen (Wharton School) and Bernd Liepert (Executive Board of KUKA Robotics) addressed this subject. Moreover, one of the founders of Operations Research, Saul Gass (University of Maryland), gave the opening speech on the early history of Operations Research.

This volume contains 93 papers presented at the conference, selected by the program committee and the section chairs, forming a representative sample of the various subjects dealt with at Operations Research 2008. The volume follows the structure of the conference, with 12 sections, grouped into six "Fields of Applications" and six "Fields of Methods and Theory". This structure in no way means a separation of theory and application, which would be detrimental in Operations Research, but displays the large spectrum of aspects in the focus of the papers. Of course, most papers present theory, methods and applications together.

Like at the conference, the largest number of papers falls into the Section "Discrete and Combinatorial Optimization" (11 papers) and into the Logistics Sections "Supply Chain and Inventory Management" (11 papers) and "Traffic and Transportation" (18 papers), which are closely related to the global business issue. The papers of the winners of the Diploma and Dissertation Awards have already been published in the OR News No. 34 of November 2008, edited by GOR.

We would like to thank everybody who contributed to the great success of the conference, in particular the authors of the papers and all speakers of the conference, the program committee and the section chairs who have acquired the presented papers and refereed and selected the papers for this volume.

Moreover, we express our special thanks to our staff members Dipl.-Wirtsch.-Inform. Oliver Faust, Dipl.-Kfm. Christoph Pitzl, Dipl.-Wirtsch.-Inform. Claudius Steinhardt, Dipl.-Math. oec. Thomas Wörle and particularly to Marion Hauser and Dipl.-Wirt.-Inf. Ramin Sahamie for preparing the final manuscript of this volume. We are grateful for the pleasant cooperation with Barbara Feß and Dr. Werner Müller from Springer and their professional support in publishing this volume.

Augsburg, December 2008

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Part I

Finance and Accounting

Smoothing Effects of Different Ways to Cope with Actuarial Gains and Losses Under IAS 19

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1 Research Question

International accounting for pension obligations is one of the most complex issues in accounting. According to the International Accounting Standard (IAS) 19 'employee benefits' the defined benefit obligation has to be measured by the *projected unit credit method* (IAS 19.64). Experience deviations from the expected values for future salary/wage increases, pension increases, fluctuation, and mortality as well as changes in the discount rate cause actuarial gains and losses, that are explicitly considered within the IAS 19 accounting system. Actuarial gains and losses are unavoidable to a certain degree and may cause fluctuations in pension costs. IAS 19 offers several ways to cope with actuarial gains and losses. The so-called *corridor approach* is explicitly designed to smooth pension costs (IAS 19 BC 39; see [1, p. 127]).
Generally, smoothing is contrary to the overall objective to provide information that is useful for economic decision. The research question of this paper is to quantify the smoothing effects of the different ways to cope with actuarial gains and losses. Furthermore, we suggest a modification that results into a moderate smoothing, but without a loss of decision usefulness, because it avoids an artificial source of actuarial gains and losses and reduces complexity.
As we are interested in pure accounting effects we focus on unfunded pension plans. Thus, the results are not influenced by the design of the entities contributions to an external fund as well as the investment policy of such a fund.

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DOI: 10.1007/978-3-642-00142-0_1,

2 Different Ways to Cope with Actuarial Gains and Losses Under IAS 19

The current IAS 19 provides different ways to cope with actuarial gains and losses:

1. *Corridor approach with amortizing recognition*: cumulation and recognition of a corridor excess over the expected remaining working lives of the participating individuals (IAS 19.92)
2. *Corridor approach with immediate recognition*: cumulation and a faster recognition of a corridor excess, in particular recognition of a corridor excess in the current period (IAS 19.93, 93A)
3. *Immediate recognition in profit and loss* (IAS 19.93, 93A)
4. *Equity approach*: immediate recognition outside profit and loss in a separate statement directly within equity (IAS 19.93A)

The standard method of IAS 19 is the *corridor approach* with a amortization of a corridor excess over the expected remaining working lives of the participating individuals (no 1). For the considered unfunded pension plans, the corridor is 10 % of last years defined benefit obligation (IAS 19.92). This method defines the minimum amount of actuarial gains and losses to be recognised in the current period. IAS 19.93 allows a faster systematical recognition of cumulated actuarial gains and losses even within the corridor width of 10 %. This means that (a) we can amortize a corridor excess within a shorter period (IAS 19.93A explicitly allows to recognise a corridor excess in the current period – no 2), or (b) we can apply a corridor width lower than 10 %, or (c) a combination of both, (a) and (b). In fact, the *immediate recognition in profit and loss* (no 3) could be interpreted as the extreme case of the *corridor approach* with a corridor width of 0 % and an immediate recognition of the corridor excess.

Generally, the aim of the *corridor approach* is to avoid huge fluctuations in pension costs caused by errors in estimating the actuarial assumptions. The *corridor approach* requires additional records outside the financial statement and increases complexity of the system of accounting for pension obligations. The *equity approach* (no 4) has been adopted from the British Financial Reporting Standard (FRS) 17 'Retirement Benefits' in 2004. Because of the immediate recognition of actuarial gains and losses outside profit and loss, the pension costs are never affected by actuarial gains and losses. As a consequence, the *equity approach* reduces complexity and achieves the maximal possible smoothing of pension costs but at the price of incompleteness of costs that is contrary to 'clean accounting'.

3 Design of a Simulation Study

An analytical approach for quantifying the smoothing effects of the different approaches is not possible. Therefore, Monte Carlo simulation analysis is the method of choice. The simulation model has been characterized in [3]. We consider a *regenerating workforce*, in which an individual substitutes for an other individual who fluctuates, retires or dies. Each simulation run consists of 500 iterations.
The assumptions concerning the financial and non financial parameters are based on official German statistics (For a detailed reference see [2].). In order to generate mutually compatible financial assumptions we simulate the vector-autoregressive model presented in [3]. Contrary to [2] and [3] we focus only on smoothing. Therefore, we first have to differentiate smoothing from uncertainty which is shown in standard graphical simulation outcomes.
We are not interested in the variation of pension costs at a certain point in time during all iterations of a simulation run (uncertainty), but we are interested in the variation of pension costs during the simulation period within a single iteration of the simulation run (smoothing). Furthermore, to measure smoothing, it is not adequate to take the statistical 'variance' of the pension costs at the different points in time of a single iteration (see Fig. 1).

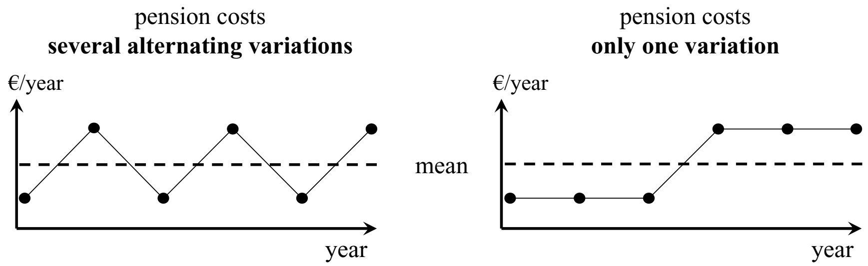

Fig. 1. Identical variance but different smoothing

For illustration, both diagrams of Fig. 1 show a time series of pension costs that have an identical statistical 'variance'. It is obvious that the diagram on the right hand side has only one variation and therefore a better smoothing than the diagram on the left hand side with several alternating variations. Therefore, we use the *annual average absolute changes of the pension costs* as a *smoothing criterion*. A low value of this criterion indicates a high smoothing.

Among the assumptions, the discount rate is a kind of artificial source of variations of the pension costs. IAS 19.78 requires to determine the discount rate from current market yields of long-term highly quality corporate bonds. The *projected unit credit method* is one of several possible cost allocation methods. In actuarial science and practice this method applies a *constant discount rate*. IAS 19 takes this long-term allocation technique from actuarial science and mixes it with the short-term 'fair value' idea. As a result, we get huge fluctuations in the pension costs that are due to fluctuations of the discount rate. We have to keep in mind, that the decision for a special discount rate does not have any cash consequences and controlls only the allocation of the total pension payments to the periods. Furthermore, the estimation of the value of the defined benefit obligation by one of several possible methods does not become more precise, just by taking a discount rate based on current market yields. Therefore, besides the *variable discount rate* required by IAS 19.78, we also consider a *constant discount rate* according to the original actuarial concept of the *projected unit credit method*.
In the simulation study we compare the following approaches using a *variable discount rate* as well as a *constant discount rate*:

- *Corridor approach with amortizing recognition* of the corridor excess
- *Corridor approach with immediate recognition* of the corridor excess
- *Equity approach*

Furthermore we vary the corridor width from 0 % in steps by 5 % to 20 % of last years defined benefit obligation. The combination 'corridor approach/immediate recognition/corridor width 0 %' represents the *immediate recognition of total actuarial gains and losses in profit and loss* (no 3 in Sect. 2) (IAS 19.93, 93A).

4 Quantitative Results for a Regenerating Workforce

The following Fig. 2 shows the quantitative results for the simulation analysis for a *regenerating workforce*.
As a remark, we have to remember, that the *equity approach* excludes actuarial gains and losses from the pension costs. Therefore, it's smoothing is an experimentally generated lower bound for the smoothing criterion of the other approaches. In Fig. 2 the big } describes the spread of smoothing, that is offered by the current IAS 19. In addition, the ◯ represents the *immediate recognition of actuarial gains and losses in profit and loss* in case of a *constant discount rate*.

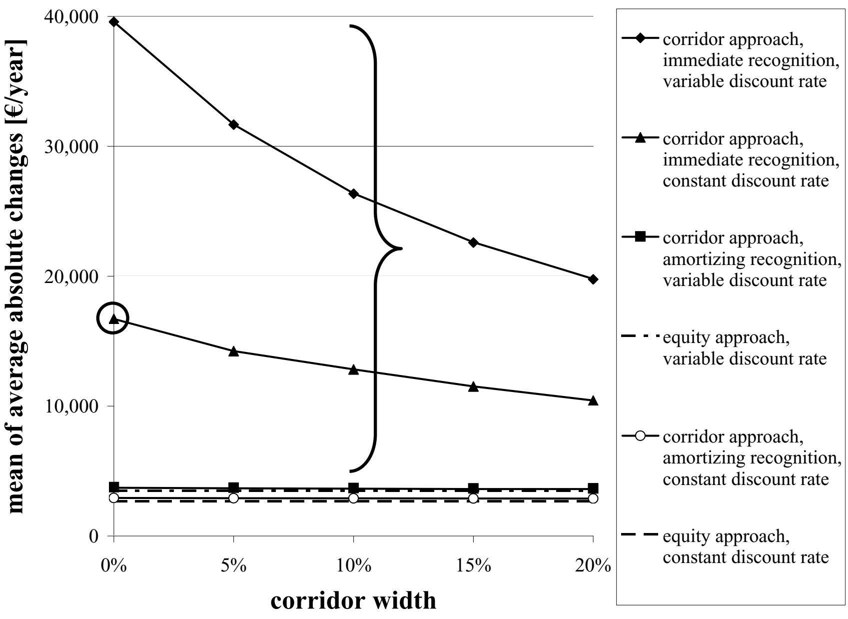

Fig. 2. Smoothing of pension costs

The quantitative results are the following:

- Regardless of the kind of discount rate or the corridor width, there is only a small difference between the *corridor approach with amortizing recognition* of the corridor excess and the *equity approach.*
- For the *corridor approach with amortizing recognition* of the corridor excess there is only little difference in the smoothing criterion if we change from a *variable discount rate* to a *constant discount rate.*
- For the *corridor approach with immediate recognition* of the corridor excess there is a considerable stronger smoothing when we apply a *constant discount rate* instead of a *variable discount rate.*
- The most important quantitative result is, that smoothing achieved by using a *constant discount rate* in case of an *immediate recognition of actuarial gains and losses in profit and loss* (illustrated by the circle ◯ in Fig. 2) is within the range that is accepted by the current IAS 19 (illustrated by the big } in Fig. 2).

5 Consequences

Generally, smoothing should be avoided as it causes bias in accounting information. Because for this and some other reasons (see [2] and [3]), the *equity approach* as well as the *corridor approach* – especially in case of an amortization of a corridor excess – are contrary to the overall objective to provide useful information for economic decisions of investors and other stakeholders.

But it is possible to avoid artificial fluctuations of pension cost which are caused by the use of a *variable discount rate* instead of a *constant discount rate* as in the original actuarial cost allocation approach of the *projected unit credit method*. Mixing different principles from both disciplines – actuarial science (the allocation mechanism of the *projected unit credit method*) and accounting (the 'fair value' concept based on current data) – results in undesirable problems as it causes avoidable fluctuations in pension costs and requires either a complex mechanism (the *corridor method*) or a kind of 'dirty accounting' (the *equity method*) to repair this effect.

The *immediate recognition of actuarial gains and losses in profit and loss* while applying a *constant discount rate* for measuring the defined benefit obligation results to a moderate smoothing that is within the range accepted under the current IAS 19. Thus, this simple modification should be regarded as reasonable alternative for the amendment of IAS 19. It is just the application of a actuarial cost allocation method that avoids artificial fluctuations in pension costs at a reduced complexity.

As a final remark, the recently issued discussion paper 'Preliminary Views on Amendments to IAS 19 Employee Benefits' (March 2008) copes with three approaches that differ in the way the amount of actuarial gains and losses is recognized in profit and loss or in other comprehensive income. The *corridor approach* as well as the *equity approach* could be expected to be repealed. Unfortunately, a change toward a *constant discount rate* is not yet addressed by the International Accounting Standards Board (IASB).

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A Regime-Switching Relative Value Arbitrage Rule

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1 Introduction

The relative value arbitrage rule, also known as "pairs trading" or "statistical arbitrage", is a well established speculative investment strategy on financial markets, dating back to the 1980s. Today, especially hedge funds and investment banks extensively implement pairs trading as a long/short investment strategy.[1]

Based on relative mispricing between a pair of stocks, pairs trading strategies create excess returns if the spread between two normally comoving stocks is away from its equilibrium path and is assumed to be mean reverting, i.e. deviations from the long term spread are only temporary effects. In this situation, pairs trading suggests to take a long position in the relative undervalued stock, while the relative overvalued stock should be shortened. The formation of the pairs ensues from a cointegration analysis of the historical prices. Consequently, pairs trading represents a form of statistical arbitrage where econometric time series models are applied to identify trading signals.

However, fundamental economic reasons might cause simple pairs trading signals to be wrong. Think of a situation in which a profit warning of one of the two stocks entails the persistant widening of the spread, whereas for the other no new information is circulated. Under these circumstances, betting on the spread to revert to its historical mean would imply a loss.

To overcome this problem of detecting temporary in contrast to longer lasting deviations from spread equilibrium, this paper bridges the literature on Markov regime-switching and the scientific work on statistical

[1] For an overview see [7, 3].

B. Fleischmann et al.(Eds.), *Operations Research Proceedings 2008,*
DOI: 10.1007/978-3-642-00142-0_2,

arbitrage to develop useful trading rules for "pairs trading". The next section contains a brief overview of relative value strategies. Section 3 presents a discussion of Markov regime-switching models which are applied in this study to identify pairs trading signals (section 4). Section 5 presents some preliminary empirical results for pairs of stocks being derived from DJ STOXX 600. Section 6 concludes with some remarks on potential further research.

2 Foundations of Relative Value Strategies

Empirical results, documented in the scientific literature on relative value strategies, indicate that the price ratio $Rat_t = \left(P_t^A / P_t^B\right)$ of two assets A and B can be assumed to follow a mean reverting process [3, 7]. This implies that short term deviations from the equilibrium ratio are balanced after a period of adjustment. If this assumption is met, the "simple" question in pairs trading strategies is that of discovering the instant where the spread reaches its maximum and starts to converge. The simplest way of detecting these trading points is to assume an extremum in Rat_t when the spread deviates from the long term mean by a fixed percentage. In other cases confidence intervals of the ratio's mean are used for the identification of trading signals.[2] Higher sophisticated relative value arbitrage trading rules based on a Kalman filter approach are provided in [2, 1].

Pairs trading strategies can be divided into two categories in regard to the point in time when a trade position is unwinded. According to conservative trading rules the position is closed when the spread reverts to the long term mean. However, in risky approaches the assets are held until a "new" minimum or maximum is detected by the applied trading rule.

However, one major problem in pairs trading strategy - besides the successful selection of the pairs - stems from the assumption of mean reversion of the spread. Pairs traders report that the mean of the price ratio seems to switch between different levels and traditional technical trading approaches often fail to identify profit opportunities. In order to overcome this problem of temporary vs. persistent spread deviations, we apply a Markov regime-switching model with switching mean and switching variances to detect such phases of imbalances.

[2] See [3].

3 Markov Regime-Switching Model

Many financial and macroeconomic time series are subject to sudden structural breaks [5]. Therefore, Markov regime-switching models have become very popular since the late 1980s. In his seminal paper Hamilton [4] assumes that the regime shifts are governed by a Markov chain. As a result the current regime s_t is determined by an unobservable, i.e. latent variable. Thus, the inference of the predominant regime is based only on calculated state probabilities. In the majority of cases a two-state, first-order Markov-switching process for s_t is considered with the following transition probabilities [6]:

$$prob\left[s_t = 1|s_{t-1} = 1\right] = p = \frac{\exp\left(p_0\right)}{1+\exp\left(p_0\right)} \tag{1}$$

$$prob\left[s_t = 2|s_{t-1} = 2\right] = q = \frac{\exp\left(q_0\right)}{1+\exp\left(q_0\right)}, \tag{2}$$

where p_0 and q_0 denote unconstrained parameters. We apply the following simple regime-switching model with switching mean and switching variance for our trading rule:

$$Rat_t = \mu_{s_t} + \varepsilon_t, \tag{3}$$

where $E\left[\varepsilon_t\right] = 0$ and $\sigma^2_{\varepsilon_t} = \sigma^2_{s_t}$.
To visualize the problem of switching means figure 1 plots a time series of a scaled price ratio, where the two different regimes are marked. The shaded area indicates a regime with a higher mean (μ_{s_1}) while the non-shaded area points out a low-mean regime (μ_{s_2}).
Traditional pairs trading signals around the break point BP would suggest an increase in Rat_{BP} implying a long position in Anglo American PLC and a short position in XSTRATA PLC. As can be seen in figure 1 this trading position leads to a loss, since the price of the second stock relative to the price of the first stock increases.

4 Regime-Switching Relative Value Arbitrage Rule

In this study we suggest applying Markov regime-switching models to detect profitable pairs trading rules. In a first step we estimate the Markov regime-switching model as stated in equation (3). As a byproduct of the Markov regime-switching estimation we get the smoothed probabilities $P(\cdot)$ for each state. Based on these calculated probabilities we identify the currently predominant regime. We assume a two-state process for the spread and interpret the two regimes as a *low* and

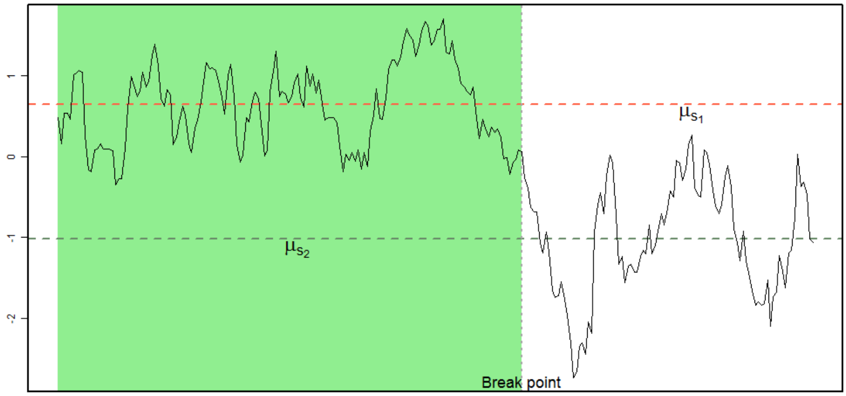

Fig. 1. Scaled ratio of the stock prices of Anglo American PLC and XSTRATA PLC from 2006-12-01 to 2007-11-15. The ratio exhibits a switching mean. The shaded area indicates the high mean regime.

a *high* mean regime. In consequence, we try to detect the instant where the spread Rat_t reaches a local extremum. As a matter of convenience, we adopt the traditional pairs trading approach that a minimum or maximum is found when the spread deviates from the mean by a certain amount. However, we extend the traditional rule by considering a low and a high mean regime, and so we create a regime dependent arbitrage rule. A trading signal z_t is created in the following way:

$$z_t = \begin{cases} -1 \;\; if \;\; Rat_t \geq \mu_{s_t} + \delta \cdot \sigma_{s_t} \\ +1 \;\; if \;\; Rat_t \leq \mu_{s_t} - \delta \cdot \sigma_{s_t}, \end{cases} \tag{4}$$

otherwise $z_t = 0$. We use δ as a standard deviation sensitivity parameter and set it equal to 1.645. As a result, a local extremum is detected, if the current value of the spread lies outside the 90% confidence interval within the prevailing regime. The interpretation of the trading signal is quite simple: if $z_t = -1$ (+1) we assume that the observed price ratio Rat_t has reached a local maximum (minimum) implying a short (long) position in asset A and a long (short) position in asset B.

Probability Threshold

To evaluate the trading rule dependent on the current regime (*low* or *high* mean), we additionally implement a probability threshold ρ in our arbitrage rule. Therefore, the regime switching relative value arbitrage rule changes in the following way:

$$z_t = \begin{cases} -1 \;\; if \;\; Rat_t \geq \mu_{low} + \delta \cdot \sigma_{low} \wedge P(s_t = low|Rat_t) \geq \rho \\ +1 \;\; if \;\; Rat_t \leq \mu_{low} - \delta \cdot \sigma_{low} \end{cases} \tag{5}$$

otherwise $z_t = 0$, if s_t is in the *low mean regime*. In the *high mean regime* a trading signal is created by:

$$z_t = \begin{cases} -1 \;\; if \;\; Rat_t \geq \mu_{high} + \delta \cdot \sigma_{high} \\ +1 \;\; if \;\; Rat_t \leq \mu_{high} - \delta \cdot \sigma_{high} \wedge P(s_t = high|Rat_t) \geq \rho \end{cases} \tag{6}$$

otherwise $z_t = 0$. The probabilities $P(\cdot)$ of each regime indicate whether a structural break is likely to occur. If the probability suddenly drops from a high to a lower level, our regime switching relative value arbitrage rule prevents us from changing the trading positions the wrong way around, so that a minimum or a maximum is not detected too early. The probability threshold value is set arbitrarily. Empirical results suggest a setting for ρ ranging from 0.6 to 0.7. Therefore, the trading rule acts more cautiously in phases where the regimes are not selective.

5 Empirical Results

The developed investment strategy is applied in a first data set to the investing universe of the DJ STOXX 600. Our investigation covers the period 2006-06-12 to 2007-11-16. We use the first 250 trading days to find appropriate pairs, where we use a specification of the ADF-test for the pairs selection. The selected pairs[3] are kept constant over a period of 50, 75, 100 and 125 days. However, if a pair sustains a certain accumulated loss (10%, 15%), it will be stopped out. To estimate the parameters of the Markov regime-switching model we use a rolling estimation window of 250 observations.

For reasons of space, only one representative example will be quoted. Table 1 demonstrates the results of the regime-switching relative value arbitrage rule for the second term of 2007. In this period the best result (average profit of 10.6% p.a.) is achieved by keeping the pairs constant over 125 days and by a stop loss parameter of 15%. The setting of 50 days with a stop loss of 10% generates an average loss of -1.5% p.a. It should be noted that the trading and lending costs (for short selling) have not been considered in this stage of the study.

[3] A number of 25 was detected. One asset is only allowed to occur in 10% of all pairs because of risk management thoughts.

Table 1. Annualized descriptive statistics for the over all selected pairs averaged results of the second term of 2007. # denotes the number of pairs not leading to a stop loss.

panel	50 days		75 days		100 days		125 days	
stop loss	10%	15%	10%	15%	10%	15%	10%	15%
μ	-0.01470	0.00555	0.05022	0.07691	0.03038	0.05544	0.08196	0.10617
σ	0.17010	0.17568	0.18181	0.19042	0.19105	0.20417	0.21265	0.23059
min	-0.40951	-0.40951	-0.29616	-0.38670	-0.23157	-0.23402	-0.19000	-0.22644
1Q	-0.21938	-0.18922	-0.15507	-0.08395	-0.23157	-0.10718	-0.19000	-0.19000
2Q	0.00000	0.00823	0.00000	0.09495	-0.02199	0.05935	0.06252	0.06785
3Q	0.18277	0.18277	0.21685	0.21685	0.18718	0.18718	0.23587	0.23587
max	0.79171	0.79171	0.84898	0.84898	0.60407	0.60407	1.27242	1.27242
#	23	24	21	24	18	23	15	19

6 Conclusion

In this study we implemented a Markov regime-switching approach into a statistical arbitrage trading rule. As a result a regime-switching relative value arbitrage rule was presented in detail. Additionally, the trading rule was applied for the investing universe of the DJ STOXX 600. The empirical results, which still remain to be validated, suggest that the regime-switching rule for pairs trading generates positive returns and so it offers an interesting analytical alternative to traditional pairs trading rules.

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