MANAGEMENT STRATEGIES AND DYNAMIC FINANCIAL ANALYSIS

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JEL Classification: C15, G22, G31, G32

ABSTRACT

Dynamic Financial Analysis (DFA) has become an important tool for analyzing the financial situation of an insurance company. Over the last years, a constant development and documentation of DFA tools has taken place. However, there are several questions concerning the implementation of DFA systems that have not been entirely answered in the DFA literature to date. One important issue is the consideration of management strategies in the DFA context. The aim of this paper is to study the effects of different management strategies on the insurer’s risk and return profile for a non-life insurance company. Therefore, we develop several management strategies and test them numerically within a DFA simulation study.

1. INTRODUCTION

Against the background of substantial changes in competition, capital market conditions, and supervisory frameworks, holistic analysis of an insurance company’s assets and liabilities takes on special relevance. One important tool in this context is Dynamic Financial Analysis (DFA). DFA is a systematic approach to financial modeling in which financial results are projected under a variety of possible scenarios by showing how outcomes are affected by changing internal and/or external conditions. The ongoing discussion in Europe about new risk based capital standards (Solvency II), the development of International Financial Reporting Standards (IFRS), as well as expanding catastrophe claims have made DFA an important tool for cash flow protection and decision making, especially in the non-life and reinsurance businesses (for an overview, see Eling/Parnitzke, 2006).

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However, there are several issues in implementing a DFA system for a non-life insurance company that have not been considered deeply in the DFA literature so far. One of the most important aspects is the integration of management strategies in DFA, which is the aim of this paper. We see two reasons why modeling management is essential to proper DFA. First, management behavior reflects the company’s reaction to its environment and its financial situation. Thus suitable management rules are needed so as to make multi-period DFA more meaningful. Second, management can use DFA to test different strategies and learn from the results in a theoretical environment, thereby hopefully preventing costly "mistakes" in reality. Management responses include long term strategies as well as management rules, which are rather short term decisions and reactions to actual needs (for the distinction between strategies and rules see Brinkmann/Gauß/Heinke, 2005, p. 170).

The literature contains several surveys and applications of DFA. The DFA Committee of the Casualty Actuarial Society started developing simulation models for use in a property-casualty context in the late 1990s; the committee’s results are reported in a DFA handbook (see Casualty Actuarial Society, 1999). In form of an overview, Blum/Dacorogna (2004) present elements and main value proposition of DFA use. Lowe/Stanard (1997) and Kaufmann/Gadmer/Klett (2001) both provide an introduction to this field by presenting a model framework, followed by an application of the model. Lowe/Stanard (1997) present a DFA model used by a property-catastrophe reinsurer to handle the underwriting, investment, and capital management process. Kaufmann/Gadmer/Klett (2001) give a model framework comprising the components most DFA models have in common and integrate these components in an up-and-running model. Blum et al. (2001) use DFA for modeling the impact of foreign exchange risks on reinsurance decisions; D’Arcy/Gorvett (2004) apply DFA to determine whether an optimal growth rate in the property-casualty insurance business can be found. Using data from a German non-life insurance company, Schmeiser (2004) develops an internal risk management approach for property-liability insurers based on DFA, an approach that European Union-based insurance companies might use as an internal model to calculate their risk-based capital required under Solvency II.

Up to now the implementation of management strategies and rules is mentioned as a necessary step to improve DFA (see, e.g., D’Arcy et al., 1997, pp. 11–12, Blum/Dacorogna, 2004, p. 518). Although DFA is regularly discussed as a help-
ful tool to test management strategies and rules (see, e.g., D’Arcy et al., 1997, p. 23, Wiesner/Emma, 2000, p. 81), very little literature directly addresses the implementation of such rules. Among the literature on DFA, Daykin/Pentikäinen/Pesonen (1994, pp. 369–407) discuss the implementation of response function to changes on the insurance market. However, only a discussion of possible management reactions to market changes is provided; the authors do not consider a holistic model of an insurer that pictures the effects of certain management strategies. The same holds true for Brinkmann/Gauß/Heinke (2005), who present a discussion of management rules within a stochastic model for the life insurance industry and give examples for the implementation of such rules. Brinkmann/Gauß/Heinke (2005) only present a theoretical discussion of these issues, but their aim is not to show practical implementations or to evaluate implications for DFA decision making.

The goal of this paper is to implement different management strategies in DFA and to study their effects on the insurer’s risk and return position. We present performance measures, which reflect both risk and return of these strategies in a multi-period context. However, the implementation of different management strategies is not related to one specific objective function of the company. Moreover, the aim of this study is to compare DFA with and without the implementation of specific management strategies regarding different risk and return figures in order to give hints regarding the long term planning process of an insurer.

Our starting point will be a DFA framework, which only contains the main elements of a non-life insurance company (Section 2). Then we will develop typical management reactions to the company’s financial situation in Section 3. In Section 4 we define financial ratios, which reflect both risk and return of these strategies in a DFA context. Section 5 will be a DFA simulation study to test the management strategies and to examine their effects on risk and return. We conclude in Section 6.

2. Model Framework
2.1. Basic Model

We denote $EC$ as the equity capital of the insurance company and $E$ as the company’s earnings. For a time period $t \in T$ the following basic relation for the development of the equity capital is obtained:
The earnings \( E_t \) per period are composed of the investment result \( I_t \) and the underwriting result \( U_t \):

\[
E_t = I_t + U_t.
\]  

For the asset part, high risk and low risk investments can be taken into account. The high risk investments typically consist of stocks, high-yield bonds or alternative investments such as hedge funds and private equity. The low risk investments are mainly government bonds or money market instruments. The portion of the high risk investment in the time period \( t \) is denoted by the parameter \( \alpha_t \). The rate of return of the high risk investment in \( t \) is given by \( r_{zt} \) and the return of the low risk investment in \( t \) is denoted by \( r_{2t} \). The rate of return of the company’s investment portfolio in \( t \), \( r_{pt} \), is given by:

\[
r_{pt} = \alpha_{t-1} \cdot r_{zt} + (1 - \alpha_{t-1}) \cdot r_{2t}.
\]  

The investment result of the company can be calculated by multiplying the portfolio return with the funds available for investments, i.e. the equity capital and the received premiums \( P_{t-1} \) less the acquisition expenses \( E_{pt}^{p} \):

\[
I_t = r_{pt} \cdot (EC_{t-1} + P_{t-1} - E_{pt}^{p}).
\]  

The other major portion of the insurance companies result is generated by the underwriting business. We denote \( \beta_t \) as the company’s portion of the associated relevant market volume in \( t \). Thereby we assume that \( \beta = 1 \) represents the whole underwriting market accessible to the insurance company. The volume of this underwriting market is denoted by \( MV \). Hence, the total premium income can be obtained from:

\[
P_{t-1} = \beta_{t-1}MV.
\]  

The claims are denoted by \( C \) and the expenses by \( Ex \). The expenses consist of the acquisition costs \( E_{pt}^{p} \) and claim settlement costs \( E_{tc}^{c} \). The acquisition expenses are calculated as a proportion of the premiums \( (E_{pt}^{p} = \gamma \beta_{t-1}MV) \), while the claim settlement costs depend directly on the claims incurred \( (E_{tc}^{c} = \delta C_t) \). Thus, we obtain the underwriting result with the relation:
$U_t = P_{t-1} - C_t - E x_{t-1}^\alpha - E x_t^\beta.$ \hspace{1cm} (6)

In this model we have two variables, which can be changed by the management of the insurance company at the beginning of each period $t$. The variable $\alpha$ denotes the portion of the risky investment and $\beta$ stands for the market share in the underwriting business.

2.2. MODEL EXTENSIONS

In addition to the basic model, we want to analyze an extended model, which contains some features of special relevance in the context of management rules. First, we implement underwriting cycles. Hence, the achievable premium level differs depending on the prevailing market phase, which might be anticipated by the management. Second, expanding or reducing underwriting business is aligned with non-linear costs. This leads to additional costs when changing the underwriting portfolio. Third, we integrate tax payments in the model.

We assume that the underwriting cycle follows a Markov process. Thereby, so called transition probabilities exist, which indicate the probability that the underwriting cycle switch from one state to another (for this approach see Kaufmann/Gadmer/Klett, 2001, pp. 229–230). We use a business cycle with three possible states. State 1 denotes a very sound market phase, which leads to a high premium income. For the second state we assume a medium premium level as in the basic model. The third state stands for a soft market phase combined with a low premium level. The variables $p_{ij}$ denote the probabilities of change from one state to another. The transition matrix can thereby be written as:

$$
\begin{pmatrix}
  p_{11} & p_{12} & p_{13} \\
  p_{21} & p_{22} & p_{23} \\
  p_{31} & p_{32} & p_{33}
\end{pmatrix}.
$$ \hspace{1cm} (7)

For instance, being in state 1, $p_{11}$ denotes the probability to stay in state 1. The probability $p_{12}$ ($p_{13}$) stands for the probability to move to state 2 (3). The underwriting cycle has a direct influence on the premium income given in Equation (5). The modified premium income is now calculated using an underwriting cycle factor $\pi^s$ for the three states $s = 1,2,3$, which changes Equation (5) to $P_{t-1} = \pi_{t-1}^s \beta_{t-1}^1 MV$. 

Raising or lowering the underwriting business is combined with additional costs, e.g., for advertisement and other efforts for sales and distribution. In an extended model we want to treat these costs with a quadratic cost function. Thus, the acquisition expenses change to
\[ \text{Ex}_{t-1}^p = \gamma \beta_{t-1} MV + \varepsilon ((\beta_{t-1} - \beta_{t-2}) MV)^2. \]

We further include taxes to be paid contingent on positive earnings. When the tax rate is given by \( tr \), Equation (2) changes to:

\[ E_t = I_t + U_t - \max(tr \cdot (I_t + U_t), 0). \] (8)

3. MANAGEMENT STRATEGIES

A crucial point to add realism to the projections provided by DFA is to incorporate management strategies into the model. Especially in long-term planning, the inclusion of management strategies provides a more reliable basis for decision making and appropriate business strategies can be identified more easily.

However, most DFA models contain only little of these management responses up to now. Therefore our aim is to present a framework, which allows an implementation of management rules and strategies. The rules presented in this paper are response mechanisms to the actual financial situation of the insurance company. Thereby, the portion of the risky investment \( \alpha \) and the market participation rate \( \beta \) are dynamically adjusted. In this context three basic questions can be formulated:

What is the aim of the management (the target)?

The strategy followed by the management is mostly a complex setting of different business objectives (e.g., the maximization of profits, the satisfaction of stakeholder demands, or the maximization of the managers own utility). On the one side, strategies might require fast interventions in case of dangerous financial situation. On the other side, they can also be less time-critical e.g., when regarding the growth target or the long-term profit maximization. The design of the current management strategy can thus be manifold, depending on the actual situation of the enterprise and the aims of the management. One possible strategy is to reduce risk in a distressed situation to avoid insolvency. Otherwise, management can do exactly the opposite thing, namely increase the risk. Keeping in mind the
limited liability of insurance companies, this might be quite rational from the viewpoint of the shareholders since their return profile corresponds to a call option. Moreover, management strategies can also be used if the insurer is in a good financial situation. Again, managers might follow two strategies, either they prefer an increase in risk, e.g., for enhancing income from option programs or a reduction of risk, e.g., to fix a certain level of profits.

Combinations of both strategies might be rational as well. A reasonable motivation for such a combined strategy is the loss aversion regarding the compensation of the management. This means a risk reduction strategy in case that the equity capital and earnings are above a certain level, protecting the reached income level. An increase in risk, if the equity capital is under a certain level, can be motivated, e.g., by the wish of the management to safe their job position.

*When does management react (the trigger)?*

Basically, we can think of three triggers, which could induce management reactions. The first one is the absolute level of the equity capital at the end of each period. Especially in the context of the European capital standards (Solvency I) the minimum capital required (MCR) can serve as a possible critical level of equity capital. In our management rules framework we would expect management reactions in case that equity capital falls below this MCR. However, we would expect that management does not wait until the equity capital falls under the MCR, but rather that there is a safety loading of, e.g., 50% above this critical level. Thus the trigger could be the MCR plus 50%.

Instead of looking at the absolute value of equity capital it is also possible to use financial ratios. A common measure in business management is the return on investment (ROI), which gives the compounded return on the equity capital. This ratio can be compared to other investments opportunities. Another common measure from solvency analysis is the expected policyholder deficit (EPD) ratio, which is the expected loss in the default case in relation to the value of the liabilities (see Butsic, 1994).

Finally, management reactions might differ depending on the development of asset and insurance markets. Thus management does not look at the development of the total equity capital but rather looks separately at the company’s investment
and at its underwriting business. This strategy is of special relevance because many insurance companies still have separated responsibilities for the asset and for the liability side. This results in separate decisions for the asset and for the liability side of the balance sheet. A third possible trigger for management responses is so given by the company’s investment and underwriting results.

*How does the management react (the rule)*?

How does management react to a trigger event, given a certain management strategy? Following the definition of minimum capital required as given above, management might react with a risk reduction to a distressed financial situation of the company. An example would be a reduction of asset volatility in case that equity capital falls below the required solvency capital.

In our framework management can control two basic parameters. The first regulates the asset side by adjusting the portion of risky investments $\alpha$. The second controls the market participation rate $\beta$, thus acting on the liability side of the balance sheet. A third possible strategy would be a combined approach which simultaneously changes the assets ($\alpha$) and the liabilities ($\beta$).

There is a large set of rules, which can be implemented to lead a certain business strategy. The rules considered here follow a simple programming logic, i.e., an "if-then" rule is applied in the simplest case. The word "if" denotes the trigger and "then" stands for the according action which has to be executed whenever the rule is activated by the trigger. Other simple logics, as "if-then-else" or "do-while" rules are further possible options for the structure of a management rule.

Within the presented framework we can choose a large number of possible combinations between targets, triggers, and rules. In what follows we concentrate on only some of these combinations. Following the previous discussion we can identify four management strategies which are of special interest. These are summarized in Table 1.
The solvency strategy is a risk reduction strategy. For each point of time \((t = 1, \ldots, T-1)\) we decrease \(\alpha\) and \(\beta\) when equity capital falls below the minimum capital required plus a safety loading of 50%. In the case the equity capital falls below this critical level we reduce \(\alpha\) and \(\beta\) about 0.1.

**Management strategy 2: "Limited Liability"**

The limited liability strategy is a risk taking strategy and the exact opposite of the solvency strategy. Hence, in case that the equity capital falls below the required equity level (which is 1.5 times the minimum capital) we increase \(\alpha\) and \(\beta\) about 0.1.

**Management strategy 3: "Growth"**

The growth strategy combines the solvency strategy with a growth target for the insurance business. Thus it is a combined risk reduction and risk taking strategy. If the equity capital drops below the required minimum capital, the same rules are applied as in the solvency strategy. If the equity capital is above the trigger, we assume a growth in \(\beta\) of 0.1.

**Management strategy 4: "Loss Aversion"**

With the loss aversion strategy management increases risk in case of a bad financial situation and realizes gains in case of a good financial situation. Thus we increase \(\alpha\) and \(\beta\) about 0.1 if the equity capital falls below the critical value and decrease \(\alpha\) and \(\beta\) about 0.1 if the equity capital is above this trigger.
4. Measurement of Risk, Return and Performance

What measures can appropriately reflect risk, return and performance of the management strategies outlined in the previous section in a DFA context? We propose eight financial ratios given in the following Table 2.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Measure</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>E(G)</td>
<td>Expected gain per annum</td>
<td>Absolute return</td>
</tr>
<tr>
<td>ROI</td>
<td>Expected return on investment per annum</td>
<td>Relative return</td>
</tr>
<tr>
<td>σ(G)</td>
<td>Standard deviation of gain per annum</td>
<td>Total risk</td>
</tr>
<tr>
<td>RP</td>
<td>Ruin probability</td>
<td>Downside risk</td>
</tr>
<tr>
<td>EPD</td>
<td>Expected policyholder deficit</td>
<td>Downside risk</td>
</tr>
<tr>
<td>SR</td>
<td>Sharpe ratio</td>
<td>Return/total risk</td>
</tr>
<tr>
<td>SR_{RP}</td>
<td>Modified Sharpe ratio (RP)</td>
<td>Return/downside risk</td>
</tr>
<tr>
<td>SR_{EPD}</td>
<td>Modified Sharpe ratio (EPD)</td>
<td>Return/downside risk</td>
</tr>
</tbody>
</table>

Table 2: Financial ratios

With \( E(EC_\tau) - EC_0 \) we denote the expected gain in between time 0 and time \( T \). The expected gain \( E(G) \) per annum can then be written as:

\[
E(G) = \frac{E(EC_\tau) - EC_0}{T}.
\]  

(9)

\( E(G) \) represents an absolute measure of return. Against it, the return on invested capital measures a relative return. Let \( ROI \) denote the expected return on the invested equity capital of the insurance company per annum. Based on the relation:

\[
EC_0 \cdot (1 + ROI)^T = E(EC_\tau),
\]  

(10)

we obtain for the \( ROI \):

\[
ROI = \left( \frac{E(EC_\tau)}{EC_0} \right)^{\frac{1}{T}} - 1.
\]  

(11)

Risk can be any measure of adverse outcome that management considers relevant (see Lowe/Stanard, 1997, p. 347). One can distinguish between measures for total risk and measures for downside risk. The standard deviation is a measure of total risk, because it takes both the positive and the negative deviations from the expected value into account. The standard deviation of the gain \( \sigma(G) \) can be obtained from the following relation:
Besides the standard deviation, risk in the insurance context is often measured using downside risk measures like the ruin probability (RP) or the expected policyholder deficit (EPD) (see Butsic, 1994, and Barth, 2000). Downside risk measures differ from total risk measures in that only negative deviations from the expected value are taken into account. In our context the ruin probability is defined by:

$$RP = Pr(\tau \leq T),$$

whereby \( \tau = \inf \{t > 0; EC_t < 0\} \) with \( t = 1,2,...,T \) describes the first occurrence of ruin (i.e. negative equity capital). The ruin probability approach suffers from the shortcoming that it does not consider the severity of insolvency (see, e.g., Butsic, 1994, Powers, 1995). The expected policyholder deficit (EPD) approach takes this aspect into account by calculating the expected costs of ruin:

$$EPD = \sum_{t=1}^{T} E[max(-EC_t, 0)] \cdot (1 + r_f(0,t))^{-t}.$$  

Thereby, \( r_f(0,t) \) stands for the risk-free rate of return between 0 and \( t \).

In our simulation study we do not only want to take an isolated view on risk and return but rather consider measures that take both risk and return into account. But what measure can appropriately reflect both risk and return in DFA? From asset management literature we know a variety of performance measures. The most widely known is the Sharpe ratio, which measures performance by considering the relationship between the risk premium and the standard deviation of returns (see Sharpe, 1966). The risk premium is the mean excess return over the risk-free interest rate. Applying this ratio to our DFA framework the following formula is obtained:

$$SR = \frac{E(EC_T) - EC_0 \cdot (1 + r_f)^T}{\sigma(EC_T)}.  \tag{15}$$

In the numerator, the risk-free return is subtracted from the expected value of the equity capital in \( T \). Using the standard deviation as a measure of risk, the Sharpe
ratio also measures positive deviations of the returns in relation to the expected value. However, as risk is often calculated using downside measures, we also use the probability of ruin or the EPD in the denominator of the Sharpe ratio. Therefore we replace the standard deviation by the probability of ruin and the EPD, which gives the following two modified versions of the Sharpe ratio:

\[
SR_{RP} = \frac{E(EC_t) - EC_0 \cdot (1 + r_f)^t}{RP},
\]

(16)

\[
SR_{EPD} = \frac{E(EC_t) - EC_0 \cdot (1 + r_f)^t}{EPD}.
\]

(17)

5. Simulation Study

5.1. Model Specifications

Basic Model

In the simulation study a time period of \(T = 5\) years is analyzed. Decisions about the parameters \(\alpha\) and \(\beta\) can be made at the beginning of each year \((t = 0, ..., 4)\). The parameters \(\alpha\) and \(\beta\) can be changed in discrete steps of 0.1 within the range of 0 and 1. The market volume \(MV\) (i.e., \(\beta = 1\)) of the underwriting market accessible for the insurance company is set to €200 million. Our model company has a portion of \(\beta = 0.2\) in the market. The expenses depending on the premium written are given by \(Ex_t^p = 0.05\beta_{t-1}MV\).

For the development of the investments we assume normally distributed returns, which differ with respect to the chosen parameters (mean and standard deviation). We assume that the returns of the risky investment are given by \(N(0.10, 0.20)\), which means that the high risk investment has a mean return of 10% and a standard deviation of 20%. The returns of the low risk investment are determined by \(N(0.05, 0.05)\). Thus the risky assets have a higher mean return but also a higher standard deviation. The risk-free rate of return \(r_f\) is 3%. The claims \(C_t\) are modeled by using random numbers generated from a lognormal distribution with a mean of \(0.85 \cdot \beta_{t-1}MV\) and a standard deviation of \(0.1 \cdot \beta_{t-1}MV\). The expenses for the claim settlement are determined by a 5% proportion of the random claim amount (\(Ex_t^C = 0.05 \cdot C_t\)).
For the asset allocation we used data from the German regulatory authority ("BaFin"). German non-life insurance company typically invest about 40% of their money in higher risk investment such as stocks, high-yield bonds, and private equity, while the other 60% are invested in low risk investments like, e.g., government bonds or money market investments (see BaFin, 2005, Table 510). Thus we choose $\alpha = 0.40$ as the starting point for the asset allocation.

The calculation of the minimum capital required is conducted following the Solvency I rules used in the European Union. The minimum capital thresholds based on premiums are 18% of the first €50 million and 16% above that amount. The margin based on claims, which is 26% on the first €35 million, and 23% above that amount, are used if these amounts exceed the minimum equity capital requirements determined by the premium-based calculation. Following these rules we determine a minimum capital required of €8.84 million for $t = 0$. These are calculated as the maximum of 18% · €40 million and 26% · €34 million. To comply with the Solvency I rules, the insurance company is capitalized with €15 million in $t = 0$. This capitalization corresponds to an equity to premium ratio of 37.5%, which is a typically value for German non-life insurance companies (see BaFin, 2005, Table 520).

Model Extensions

The first extension is the inclusion of different market phases. For the basic model or in state 2 the premium remains unchanged ($\pi_2 = 1$). For $\beta = 1$ one can receive a premium of €200 million. For the good state 1 a higher premium can be realized and the premium income is changed by the factor $\pi_1 = 1.05$. For $\beta = 1$ the premium is €210 million. For the bad state 3 we assume a factor of $\pi_3 = 0.95$ (for $\beta = 1$; P=€190 million). The transition probabilities from one state to another are given by the following matrix:

$$
\begin{pmatrix}
0.3 & 0.5 & 0.2 \\
0.2 & 0.6 & 0.2 \\
0.1 & 0.5 & 0.4
\end{pmatrix}.
$$

The modified formula for the acquisition expenses is given by $Ex_{t-1}^p = 0.05 \beta_{t-1} MV + 0.001((\beta_{t-1} - \beta_{t-2})MV)^2$. Finally, taxes are paid at the end of each period. We assume a constant tax rate of $tr = 0.25$. 

5.2. RESULTS

Basic Model

First, we present the simulation results for the basic model. The simulation examples have been calculated on the basis of a Latin-Hypercube simulation with 100,000 iterations (see McKay/Conover/Beckman, 1979). These results are summarized in Table 3.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>No Strategy</th>
<th>Solvency</th>
<th>Limited Liability</th>
<th>Growth</th>
<th>Loss Aversion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E(G)</td>
<td>7.87</td>
<td>7.55</td>
<td>8.36</td>
<td>12.55</td>
</tr>
<tr>
<td></td>
<td>ROI</td>
<td>29.36%</td>
<td>28.60%</td>
<td>30.52%</td>
<td>38.97%</td>
</tr>
<tr>
<td>Risk</td>
<td>σ(G)</td>
<td>4.09</td>
<td>4.34</td>
<td>4.28</td>
<td>7.75</td>
</tr>
<tr>
<td></td>
<td>RP</td>
<td>0.22%</td>
<td>0.07%</td>
<td>0.85%</td>
<td>0.39%</td>
</tr>
<tr>
<td></td>
<td>EPD</td>
<td>0.004</td>
<td>0.001</td>
<td>0.042</td>
<td>0.011</td>
</tr>
<tr>
<td>Performance</td>
<td>SRε</td>
<td>1.92</td>
<td>1.74</td>
<td>1.95</td>
<td>1.62</td>
</tr>
<tr>
<td></td>
<td>SRRP</td>
<td>18.03</td>
<td>58.06</td>
<td>4.90</td>
<td>16.04</td>
</tr>
<tr>
<td></td>
<td>SREP</td>
<td>9.67</td>
<td>41.57</td>
<td>0.99</td>
<td>5.97</td>
</tr>
</tbody>
</table>

Table 3: Results for the basic model

Let us take a look at the simulation results when no management strategy is applied. We find an expected gain of €7.87 million per year with a standard deviation of €4.09 million. The expected return on the invested equity capital is 29.36%. The ruin probability is 0.22%. This is far below the ruin probability required by international regulatory authorities like, e.g., in Switzerland, where a level of 0.40% is demanded. Thus our model company is quite safe.

The company becomes even safer if the solvency strategy is applied. While the return remains nearly unchanged (the expected gain decreases about 4% from €7.87 million to €7.55 million per annum), we find much lower values for the downside risk measures. The downside risk is only at a ruin probability of 0.07% and an EPD of €0.001 million. This is less than one quarter of the value where no management strategy is applied. Thus the solvency strategy is able to avoid most insolvencies without affecting return. This also leads to much higher performance measures based on ruin probability and EPD compared to the results in the "no strategy" case. For example, the SR_{RP} of 58.06 is three times higher than with no strategy (18.03). Obviously, the solvency strategy is capable to reduce downside risk effectively and thus provides a valuable insolvency protection. Interest-
ingly, risk is not reduced if both the positive and the negative deviations from the expected value are taken into account, because the standard deviation is 6% higher than with no strategy (€4.34 million per annum versus €4.09 million per annum). The reason for this is that reducing the participation in insurance business and the fraction of risky investment changes the level of earnings among different time periods, which results in an increased standard deviation. Because of the higher standard deviation and the lower return the Sharpe ratio of this strategy is slightly lower than in the basic case.

The limited liability strategy, which is defined as the opposite of the solvency strategy, results in a converse risk and return profile compared to the solvency strategy. Compared to the model without a strategy the expected gain per annum rises about 6% from €7.87 million to €8.36 million. But we find also a strong increase in downside risk. Both ruin probability (0.85%) and EPD (€0.042 million) are much higher than in the case where no strategy is applied. As this increase in risk is much higher than the increase in return the performance measure based on downside risk are very low compared to the other strategies. The standard deviation of €4.28 million per annum is comparable to the standard deviation found with the solvency strategy. This confirms our hypothesis that the standard deviation is mainly driven by the changes in the level of earnings.

The growth strategy is much more flexible than the previous strategies. Remember that for this strategy the parameter $\beta$ must be changed at the end of each period, while with the other strategies, $\beta$ is only changed if the equity capital falls below the given trigger. Therefore we find a completely different risk return profile for this strategy. A much higher return is accompanied with a much higher risk. The expected gain per annum is now €12.55 million, which is 60% above the €7.87 million found with no management strategy. The percentage increase in risk is comparable with the increase in return. The standard deviation (€7.75 million per annum) is 89% higher and the ruin probability (0.39%) is 77% higher. The EPD (€0.011 million) is even 175% higher. The performance values for $\text{SR}_\sigma$ and $\text{SR}_{\text{RP}}$ are comparable with the "no strategy" case, while the $\text{SR}_{\text{EPD}}$ is lower. Therefore, the growths strategy represents an opportunity for those managers that want to achieve a higher return level but are also willing to take a higher risk.

The performance measurement values are much lower when the loss aversion strategy is applied. We find the lowest return of all strategies under evaluation;
the expected gain per annum is only €3.74 million. We can observe an interesting risk profile, namely a reduction of the standard deviation and an increase in the downside risk oriented ruin probability and EPD. At first it might seem surprising that loss aversion is the only strategy which is able to reduce the volatility. But there is an easy explanation for this result, because this rule is the only one where the parameters $\alpha$ and $\beta$ are reduced when equity capital is above the trigger. As equity capital is above that trigger in most cases, the volatility of the investments and of the underwriting business is rapidly reduced. Nevertheless, the loss aversion strategy provides the lowest performance of all strategies.

Model Extensions

In Table 4 we present the results for the extended model. Again we used a Latin-Hypercube simulation with 100,000 iterations. We calculated the results for the model with all extensions and for each extension separately.

Comparing the extended model with the basic model we find a lower return. The expected gain is €5.56 million per annum compared to €7.87 million per annum in the basic model. The lower return is mainly due to the tax payments of 25%, because the lower return cannot be found in the models where the underwriting cycle and the non-linear cost function are analyzed in isolation (part III. and IV. of Table 4). In the extended model the risk is higher than in the basic model. In the model with all extension the ruin probability is about 0.28% when no management strategy is applied. The comparable value is 0.22% in the basic model. The increase in risk might be due to the additional model dynamic implemented with the extensions. As the return is lower and the risk is higher, the performance of the extended model is lower than in the basic model.

The results of the management strategies confirm the findings presented for the basic model. The solvency strategy is effectively able to reduce downside risk, while the limited liability strategy increases insolvency risk. Growth provides the highest return, but also the highest standard deviation; the loss aversion shows the lowest return, but also the lowest standard deviation. Both the growth and the loss aversion strategy show a high insolvency risk.

The largest deviation in the results of the extended model is that the growth strategy increases the insolvency risk to a larger extend than in the basic model. In the extended model the ruin probability is 0.90% with the growth strategy and
0.28% when no strategy is used. Thus risk is increased by 221%, while in the basic model the ruin probability is only increased by 77%. This difference is mainly due to the non-linear acquisition costs implemented in the extended model, because we find similar results in part III. of Table 4, but not in part II and IV. However, these observations do not change the interpretation of the results presented for the basic model.

<table>
<thead>
<tr>
<th>I. All extensions</th>
<th>No Strategy</th>
<th>Solvency</th>
<th>Limited Liability</th>
<th>Growth</th>
<th>Loss Aversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return</td>
<td>E(G)</td>
<td>5.56</td>
<td>5.29</td>
<td>5.92</td>
<td>8.08</td>
</tr>
<tr>
<td></td>
<td>ROI</td>
<td>23.32%</td>
<td>22.55%</td>
<td>24.36%</td>
<td>29.85%</td>
</tr>
<tr>
<td>Risk</td>
<td>σ(G)</td>
<td>3.01</td>
<td>3.24</td>
<td>3.23</td>
<td>5.91</td>
</tr>
<tr>
<td></td>
<td>RP</td>
<td>0.28%</td>
<td>0.11%</td>
<td>1.38%</td>
<td>0.90%</td>
</tr>
<tr>
<td>Performance</td>
<td>EPD</td>
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<td>0.001</td>
<td>0.073</td>
<td>0.025</td>
</tr>
<tr>
<td></td>
<td>SRₐ</td>
<td>1.85</td>
<td>1.63</td>
<td>1.83</td>
<td>1.37</td>
</tr>
<tr>
<td></td>
<td>SRₐₑ</td>
<td>9.92</td>
<td>24.71</td>
<td>2.14</td>
<td>4.46</td>
</tr>
<tr>
<td></td>
<td>SRₐₑₑ</td>
<td>4.66</td>
<td>20.69</td>
<td>0.41</td>
<td>1.60</td>
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</table>

<table>
<thead>
<tr>
<th>II. Only underwriting cycle</th>
<th>No Strategy</th>
<th>Solvency</th>
<th>Limited Liability</th>
<th>Growth</th>
<th>Loss Aversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return</td>
<td>E(G)</td>
<td>7.94</td>
<td>7.61</td>
<td>8.44</td>
<td>12.69</td>
</tr>
<tr>
<td></td>
<td>ROI</td>
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<td>28.75%</td>
<td>30.69%</td>
<td>39.23%</td>
</tr>
<tr>
<td>Risk</td>
<td>σ(G)</td>
<td>4.16</td>
<td>4.41</td>
<td>4.37</td>
<td>7.95</td>
</tr>
<tr>
<td></td>
<td>RP</td>
<td>0.25%</td>
<td>0.07%</td>
<td>0.94%</td>
<td>0.45%</td>
</tr>
<tr>
<td>Performance</td>
<td>EPD</td>
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<td>0.001</td>
<td>0.047</td>
<td>0.013</td>
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<tr>
<td></td>
<td>SRₐ</td>
<td>1.90</td>
<td>1.73</td>
<td>1.93</td>
<td>1.60</td>
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<tr>
<td></td>
<td>SRₐₑ</td>
<td>15.80</td>
<td>57.65</td>
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<td>14.04</td>
</tr>
<tr>
<td></td>
<td>SRₐₑₑ</td>
<td>7.56</td>
<td>40.75</td>
<td>0.90</td>
<td>4.85</td>
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</table>

<table>
<thead>
<tr>
<th>III. Only non-linear acquisition costs</th>
<th>No Strategy</th>
<th>Solvency</th>
<th>Limited Liability</th>
<th>Growth</th>
<th>Loss Aversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return</td>
<td>E(G)</td>
<td>7.87</td>
<td>7.52</td>
<td>8.32</td>
<td>11.67</td>
</tr>
<tr>
<td></td>
<td>ROI</td>
<td>29.36%</td>
<td>28.52%</td>
<td>30.43%</td>
<td>37.37%</td>
</tr>
<tr>
<td>Risk</td>
<td>σ(G)</td>
<td>4.09</td>
<td>4.38</td>
<td>4.30</td>
<td>7.75</td>
</tr>
<tr>
<td></td>
<td>RP</td>
<td>0.22%</td>
<td>0.09%</td>
<td>1.02%</td>
<td>0.57%</td>
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<tr>
<td>Performance</td>
<td>EPD</td>
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<td>0.001</td>
<td>0.052</td>
<td>0.015</td>
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<tr>
<td></td>
<td>SRₐ</td>
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<td>1.93</td>
<td>1.51</td>
</tr>
<tr>
<td></td>
<td>SRₐₑ</td>
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<td>40.85</td>
<td>4.08</td>
<td>10.33</td>
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<tr>
<td></td>
<td>SRₐₑₑ</td>
<td>9.67</td>
<td>33.77</td>
<td>0.80</td>
<td>3.93</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IV. Only taxes</th>
<th>No Strategy</th>
<th>Solvency</th>
<th>Limited Liability</th>
<th>Growth</th>
<th>Loss Aversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return</td>
<td>E(G)</td>
<td>5.51</td>
<td>5.28</td>
<td>5.91</td>
<td>8.67</td>
</tr>
<tr>
<td></td>
<td>ROI</td>
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<td>22.50%</td>
<td>24.32%</td>
<td>31.22%</td>
</tr>
<tr>
<td>Risk</td>
<td>σ(G)</td>
<td>2.95</td>
<td>3.14</td>
<td>3.13</td>
<td>5.73</td>
</tr>
<tr>
<td></td>
<td>RP</td>
<td>0.25%</td>
<td>0.07%</td>
<td>1.05%</td>
<td>0.51%</td>
</tr>
<tr>
<td>Performance</td>
<td>EPD</td>
<td>0.005</td>
<td>0.001</td>
<td>0.053</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>SRₐ</td>
<td>1.87</td>
<td>1.68</td>
<td>1.89</td>
<td>1.51</td>
</tr>
<tr>
<td></td>
<td>SRₐₑ</td>
<td>11.10</td>
<td>38.21</td>
<td>2.81</td>
<td>8.53</td>
</tr>
<tr>
<td></td>
<td>SRₐₑₑ</td>
<td>6.09</td>
<td>27.42</td>
<td>0.55</td>
<td>2.92</td>
</tr>
</tbody>
</table>

Table 4: Results for the extended model
5.3 Robustness of Results

In this section various tests are performed to check the robustness of the findings. These tests are very important because the findings presented in Section 5.2 are valid only for the input parameters given in the simulation, e.g., the level of equity capital, the time horizon, or the starting values for $\alpha$ and $\beta$.

In the following we will present the results of four robustness tests. We consider the results presented in the last section as robust, if the basic relations between the analyzed management strategies remain unchanged. For example, we expect that the solvency strategy has a low return but also a low risk compared to the other strategies independent, e.g., of the equity capital level. All robustness tests have again been calculated on the basis of a Latin-Hypercube simulation with 100,000 iterations.

Variation of equity capital

The level of equity capital in $t=0$ determines the solvency level of the company. Our results might differ for a safe company with a high level of equity capital compared to a risky company with a low level of equity capital. In Section 5.2 the level of equity capital was given by €15 million. To test the implications of different equity capital levels, we vary the equity capital in $t=0$ between €10 million and €20 million with a step length of €1 million. The results are shown in Figure 1. The upper part of the figure shows the expected gain per annum and the lower part of the figure shows the ruin probability for different levels of equity capital.

With increasing level of equity capital the expected gain per annum converges against €8.3 million with no strategy, the solvency strategy and the limited liability strategy. The reason for this is that with increasing level of equity capital there is fewer shifting in the parameters $\alpha$ and $\beta$. For example with an equity capital of €20 million there is hardly a difference between these three strategies, because there are only very few cases where equity capital is below the trigger level and thus only minor changes in the parameters $\alpha$ and $\beta$. In contrast, the expected gain per annum increases with the growth strategy and decreases with the loss aversion strategy. With increasing level of equity capital there is more shifting towards a higher participation in the insurance market with the growth strat-
egy which increases the return chances, while the parameters $\alpha$ and $\beta$ are lowered with the loss aversion strategy, which lowers the return chances. However, for all strategies the basic relations remain unchanged. Thus the results of the last section are robust with respect to the expected gain per annum.

![Figure 1: Variation of equity capital in $t = 0$ between €10 and €20 million](image)

The same is true for the ruin probability, except for the growth strategy, where risk does not decrease as fast as with the other strategies. The reason for this is that it is the only strategy where the risk is increased with higher equity capital. Nevertheless the ruin probability decreases with all strategies when the equity capital rises.

**Variation of time horizon**

The time horizon might be of great importance in interpreting DFA results. The results may not be relevant to strategic decision making if the regarded time period is short. However, there are also problems concerning longer time periods, for example, data uncertainty and the variability of outputs. The longer the time
period, the more uncertain is the input data, leading to greater variability of results. In Section 5.2 we choose a time horizon of 5 years. To check the implications of different time horizons on our results, we vary the time horizon between 1 and 10 years in step length of one 1 year. The results are presented in Figure 2.

![Figure 2: Variation of time horizon between 1 and 10 years](image)

Expected gain increases the longer the time horizon. This is true for all strategies except loss aversion. With this strategy an increase in time horizon enhances the possibility to reduce $\alpha$ and $\beta$, which has an adverse impact on the return. Additionally, the longer the time horizon the higher is the ruin probability. This is true for all strategies. All basic relations between the strategies remain unchanged. Thus the results are robust regarding a variation of the time horizon.

*Variation of step length*

The step length in the development of $\alpha$ and $\beta$ determines the intensity of management reactions in our DFA study. For the presented results management can only change the parameters $\alpha$ and $\beta$ in steps of 0.1. But what if management
has larger possibilities for intervention, e.g., if it can even change in steps of 0.2? Or what if management is only willing to change small parts of the business policy, e.g. only wants to change in steps of 0.01? To see the implications of the step length on our results, we vary the step length in the development of $\alpha$ and $\beta$ between 0.01 and 0.2 in step length of 0.01. The results are shown in Figure 3.

![Figure 3: Variation of step length between 0.01 and 0.2](image)

Again we find robust results in respect to our findings in Section 5.2, because all basic relations between the strategies remain unchanged. Therefore our results are robust in respect to a variation in step lengths. While the expected gain remains nearly unchanged with no strategy, the solvency strategy and the limited liability strategy, we find a higher return with the growth and a lower return with the loss aversion strategy. The reason for this is that with increasing step length the shift intensity in the parameters $\alpha$ and $\beta$ increases. Comparable observations can be found with the ruin probability. Again the results prove to be robust.
Variation of starting values

In Section 5.2 the portion of risky investment was given by $\alpha=0.4$, while the portion of the relevant market was given by $\beta=0.2$. Of course there might be companies with more or less risky assets and there also might be companies with a smaller or larger stake in the relevant market. Thus as final robustness test we vary both starting values between 0 and 1 and examined their influence on our findings. Figure 4 shows the results if $\alpha$ is varied between 0 and 1.

![Figure 4: Variation of the starting values of $\alpha$ between 0 and 1](image)

With the expected gain we again find a robust relationship between the strategies. For all strategies there is a positive link between $\alpha$ and return. This result can also be found with the ruin probability. However, with the loss aversion strategy the increase in risk is less intensive compared to the other strategies, because it is the only strategy where risk is reduced when the equity capital is above the trigger level. This delimits the risk potential compared to the other strategies, especially if $\alpha$ is very high. Figure 5 shows the results if $\beta$ is varied between 0 and 1.
Looking at the expected gain per annum growth is the best strategy if the portion in the market is low but it is not the best strategy if this portion is high. The reason for this is that the growth potential concerning the parameter $\beta$ is the key return driver for this strategy. While this potential is very high for $\beta = 0$, it is nearly completely abolished with $\beta = 1$. However, for the other strategies and with the ruin probability we again find very robust results.

In summary, the robustness of these results confirm the findings in Section 5.2, as apart from explainable outliers none of the basic relations between the analyzed strategies changes.

6. CONCLUSION

We implemented management strategies in DFA and studied their effects on the insurer’s risk and return position. We found that the solvency strategy, which reduces the volatility of investments and underwriting business in case of a bad
financial situation, is a reasonable strategy for managers who want to protect the company from becoming insolvent. Our numerical examples show that the ruin probability can be effectively delimited if volatility of investments and underwriting business is reduced. The growth strategy, which combines the solvency strategy with a growth target for insurance business, might represent an interesting alternative for managers who want to achieve a higher return compared to the solvency strategy and are also willing to take higher risks.

Our DFA model only contains a minimum number of elements necessary for an adequately modeling an insurance company. Further, only a small range of management strategies was shown. However, the presented numerical examples already illustrate the benefit of applying management rules in a DFA framework, especially for long term planning. Thus for further research we suggest the implementation of management rules in a more complex DFA environment. We also propose to search for optimal management strategies within our model framework and to compare the optimization results with our heuristic management rules and the underlying simulation results. Both suggestions will provide more insights into the value of the management strategies in DFA.

REFERENCES


