Determination and allocation of risk-adequate equity capitalization for performance measurement

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1. Introduction

German insurance companies find themselves in a fierce competition concerning customers and investors. The primary interest of the assureds is the ongoing of the insurance company and due to that, they demand a high security of existence. Shareholders are more interested in a risk-adequate development of their capital tied up in the company. Equity capital functions first, to determine the quality of the protection and second, to serve as a basis to evaluate the value added by insurance companies. Therefore, the efficient use of equity capital in terms of risk- and return-aspects is the greatest challenge of insurance management.[1] This holds not only for insurance companies organized as stock corporations but also for public and mutual insurance companies.[2]

The determination and allocation of risk-adequate equity capital consists of two different tasks. First, the influence of business segments on the value of the company is to be evaluated which is the condition for the second task. Here, capacities are allocated to business segments which are more successful in the risk and return relation or withdrawn from business segments that are less successful. During this, diversification effects and internal charges resulting from services have to be considered.

At performance measurement[3], one should only take indicators into account that are accepted by the operational management.[4] Beneath output-related compensations also this performance measurement allows a comparison between the business segments and external benchmarks.

Equity capitalization limits the business volume and therefore the absolute performance possibilities of a division. Operational management having a defined business volume is interested in a rather small equity capital shares, because then the relative possibilities of performance are higher.

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[1] See Schradin/Willmes 2001, pp. 8.
[2] See hierzu Bushler et al. 2001.
[3] See Babbel/Stricker/Vanderhoof 1999, pp. 61; Kinder/Steiner/Willinsky 2001, pp. 286.
[4] „Rewarding division managers using company-wide performance measures creates incentives for them to ‚free-ride' on the performance of other divisions." Zimmerman 1997, p. 99.

2. Determination of the risk-adequate equity capitalization

The competition for customers and shareholders makes equity capital being the bottleneck in the production of coverage. It determines the security level of the insurer. Since the ongoing existence of the company is a condition for the fulfilment of their claims, the assureds are highly interested in a high level of equity capitalization. In contrast to that, the provision of funds by investors is carried without any consideration of the risk of financial losses, due to the investor's diversification. For the determination of risk-adequate equity capitalization one can distinguish between internal and external models. Internal models are based on risk theory. In contrast, external models have to fulfill the demands of governmental supervision and rating agencies.

Regarding a prospective fair valuation of assets A and liabilities L, the economic capital C is represented by the balance of the present value of future cash-in-flows (CIF) and cash-out-flows (COF)

$$\begin{aligned} C &= A - L \\ &= \sum_{t=0}^{T} \frac{CIF_t}{(1+i)^t} - \sum_{t=0}^{T} \frac{COF_t}{(1+i)^t} \end{aligned} \tag{2.1}$$

Internal methods mostly rely on ruin theory. The concept of ruin-probability is very close to the value-at-risk-concept.[5] Here, capital requirements are chosen in a way that the risk of insolvency does not exceed a defined value. On the basis of a given security level (1-ε) which is defined by the management, the equity capitalization can be determined by the lower partial moment zero.

$$LPM_0(C,0) = \int_{-\infty}^{0} f(c)dc \leq \varepsilon \tag{2.1}$$

The probability that the economic capital falls below zero may not exceed the limit ε. This is equivalent to the requirement that liabilities may not exceed assets. Because of the fact that the claims of the shareholders are residual, one can conclude that

[5] See Jorion 2001.

their interests are adequately considered by the ruin-probability. However, for the assured a partial fulfillment of their claims is important to consider. Therefore, the probability of ruin cannot be considered as a sufficient basis for the estimation of the risk-adequate equity capitalization. A measurement of risk is needed which also takes into account the size of the exceeding of the existing cover funds by the negative results of a period. This is possible by the expected policyholder deficit, EPD[6] which is represented by the lower partial moment one:

$$LPM_1(C,0) = \int_{-\infty}^{0} (-C) f(c) dc \qquad (2.2)$$

This variable measures the expected absolute missing coverage, which are the expected missing claims. Set in relation to the equity capital one also speaks of EPD-ratio, which may not exceed the given limit α:

$$\frac{EPD}{C} \leq \alpha \qquad (2.3)$$

The described internal method which combines elements from risk-theory and option price theory gains more and more importance.[7]

The internal methods compete with external models. Especially the insurance supervision defines a minimum provision of funds by setting equity capital requirements. Lately, new models of regulation, e.g. Basel II[8] or Solvency II[9], integrate internal methods in supervisory activities. Further, capital adequacy ratings by the rating agencies gain more and more importance. The information is used on capital and financial markets and determines the cost of capital. Both, supervisory models[10] and methods of rating agencies[11] are broadly discussed in various texts.

[6] The Expected Policyholder Deficit is developted by Butsic 1994.
[7] See Barth 2000; Cummins 2000; Myers/Read 2001.
[8] See Basel Committee on Banking Supervision 2001.
[9] For further details see KPMG 2002.
[10] In detail see Cummins/Harrington/Niehaus 1993; Hooker et al. 1996; Schradin/Telschow 1994; Schradin 1997; SwissRe 2000.
[11] For Rating of insurance companies see detailed Lanfermann 1998. An Overview of US-American insurance rating agencies is presented by Schedlbauer/Scully 1997. The S&P Modell for property/casualty insurers is explained by Standard & Poors 1999; Reactions 1997.

Because of that, the following table summarizes the main characteristics of the different models:

	Solvency Germany /EU	Risk Based Capital NAIC	Rating Model Standard & Poor's
Aim	Avoidance of insolvency	Avoidance of insolvency	Intermediation concerning information
Data	Internal accounting	Annual financial statement	Internal and external sources of information
Included Risks	Actuarial risks, Limiting investment risks by specific rules	Actuarial risks, investment risks, credit risks	Actuarial risks, investment risks, credit risks
Integration of reinsurance	Partly (max 50%), not differentiated	Indirectly through net values	Partly (max 50%)
Diversification effects Economies of scale	Not included	Inadequate	Inadequate

Table 1: Characteristics of external models for capital requirement

All methods have methodological shortcomings. The differences between the models lead to the conclusion that capital requirements in the solvency model used in Germany are lower compared to the other models. But in contrast to the risk based capital and the rating model, in Germany one can find specific capital regulation. Models used by rating agencies mostly require capitalization that is higher than risk-theoretic calculations, especially if the management strives for the highest rating class. For insurance companies, a solid financial standing is so important that often over-capitalization is taken for granted. This additional capital can also be called bonus capital and regarding return aspects it is an additional load for the management.

3. Development of a value-based model of optimization

Until now, it has been discussed how to determine the risk-adequate capital requirements. Now it is important to have a look at the efficient use of the resources. Investors expect a minimum rate of interest on their capital. Only a return which exceeds the cost of capital creates value for a company. Despite the determination of a risk-adequate capitalization it is also necessary to define a measurement for the profit and to calculate the cost of capital. There are several methods used for the calculation of the cost of capital that will not be discussed within this paper.[12]

The present value of future payments is used to determine the profit. For simplification this cash flow is modeled by payments of premium π, claim expenditures S, operating costs BK, the balance from investments I, and from reinsurance RV:

$$CF_t = \pi_t - S_t - BK_t + I_t + RV_t \tag{3.1}$$

The cash flow is stochastic. The companies economic value EV is given by the present value of expected future cash flows:

$$EV = \sum_{t=0}^{T} \frac{E(CF_t)}{(1+i)^t} \tag{3.2}$$

Regarding a single period, the economic value increases if the expected cash flow exceeds the cost of capital:[13]

$$EVA_t = E(CF_t) - rC_t \tag{3.3}$$

Assuming defined cost of capital r*, optimization can reached by maximizing the market value added:

[12] In detail see Lee/Cummins 1998.
[13] See Stoughton/Zechner 1999, p. 10.

$$\max\left\{\sum_{t=0}^{T}\frac{E(EVA_t)}{(1+i)^t}\right\} \tag{3.4}$$

with

$$\int_{-\infty}^{0} f(c)dc \le \varepsilon \tag{3.5a}$$

or

$$\frac{\int_{-\infty}^{0}(-C_t^*)f(c)dc}{C_t^*} \le \alpha \tag{3.5b}$$

If expected future payments in relation to the risk-adjusted capital do not at least match the cost of capital r*C*, capital has to be set free. Three ways to improve the relation between return and cost of capital can be identified:

a) Increase of performance
b) Reduction of risk-related capital
c) Reduction of cost of capital

More likely, these actions will influence either the performance situation or the risk situation of the company. The management of the dimensions is only possible on operative level. For doing this, operative business units are identified and examined for their contribution to the value added.

Business segments which can be considered successful in the way mentioned above get more capacities, by transferring it from less successful business segments. Each business unit i is evaluated by:

$$EVA_{it} = E(CF_{it}) - r^* C_{it}^*(\varepsilon) \overset{!}{>} 0 \tag{3.6}$$

Each business segment has an individual risk position which determines its individual cost of capital. Value is only created if the earned profit is higher than the cost of capital. Using this principle as a decision criterion causes the problem – due to the stochastic character of cash flows – of misleading managerial decisions. Enduring returns in the different segments might be difficult to accomplish.

4. Capital Allocation

4.1. Introduction

The main problem with the segmentation of business units are the stochastic dependencies between the business units. Companies combine different business units because of resulting synergy effects. In contrast to the case of autonomy of the business units, here a value added results. If a segment is independent from all other units, it is to be outsourced. Usually, it will not be possible to identify stochastically independent business units. The main problem is to allocate the synergy advantages to the business units.[14] Formally, this problem can be described as follows:[15]

$$C_t(\varepsilon) < \sum_{i=1}^{n} C_{it}(\varepsilon) \tag{4.1a}$$

or

$$C_t(\alpha) < \sum_{i=1}^{n} C_{it}(\alpha) \tag{4.1b}$$

The risk-adequate need for capital concerning the whole company is lower than the sum of the needs for capital of all individual business units. Most authors suggest to pass this advantage of diversification to the business units.[16] But measures that change the profitability within the business units also change capital allocation. A reallocation becomes necessary. It is obvious, that the result is a circularity-problem.[17]

Next, we will give a short overview of the different methods of capital allocation to the business segments. By criticizing these methods in general and individually, we explain why a renunciation of the decomposition of diversification advantages is preferable.

[14] See Zimmermann 1997, p. 102.
[15] See Schradin 2001, pp. 9.
[16] That mainly concerns on English language area, for example see Cummins 2000; James 1996; Matten1996; Merton/Perold 1993; Myers/Read 2001; Saita 1999; Singh 2002; Stoughton/Zechner 1999, 2000; Taflin 1999. German authors to be mentioned are Albrecht 1998; Hille/Burmester/Otto 2000; Kinder 1999; Kinder/Steiner/Willinsky 2001; Schierenbeck 2001; Schierenbeck/Liester 1997; Schmeiser/Gründl 2001; Schradin 1998.
[17] See Schradin 1998, pp. 228. A dynamic model is developed by Stoughton/Zechner 2000.

The methods either come from risk theory or game theory. We assume a virtual, pure imputed capital allocation. A physical allocation will not take place, first because of the regulation mentioned above. Second, it is assumed that individual risk segments do not make their own investments. Equity capital is only used for the employment in assets.

More difficult is the development of evaluation criteria that are valid and adequate for both theories. A method should be formally able to bring the alternatives in an ordinal ranking. To being able to do this, it has to be demanded that first, a linear decomposition of the overall risk into business segment risks is possible and that secondly, a consideration of stochastic dependencies between the segments is possible. At the same time, the scale has to represent the preferences of the decision maker.[18] If those formal conditions are given, the following as regard content criteria can be used:[19]

- Individual rationality (having built collectives, the capital allocation to individual business segments is not larger than it would have been with individual determination of need for capital)
- Collective rationality (pareto-optimum: the whole advantage of building collectives is being divided and allocated to the units)
- "Strohmann" characteristics (a business unit that does not give any diversification advantage to the company, does not get any advantages with the capital allocation)
- Symmetry (the capital volume a business unit gets is independent from the order of allocation)
- Monotony (the rising of need for capital in the company does not lead to a sinking capital allocation to a single business unit)

4.2. Approaches based on risk-theory

Capital allocation using risk-theoretic methods are based on risk measurements. Fundamentally, one has to distinguish between symmetric and asymmetric risk measures. Symmetric risk measures are used for volatility-based capital allocation,

[18] See Graumann/Baum 2002, pp. 17.
[19] In detail see Kinder 1999, pp. 114.

for example methods based on variance or standard deviation.[20] The problem with these methods is that they do not distinguish between exceeding or falling below the expected value of the volatility-proportional capital allocation. Here, asymmetric risk measures are used, because they register either the falling below the expected business performance or the exceeding of the expected value of loss. Aim of the method is to determine the allocation factors x_i:

$$C_t^*(\varepsilon) = \sum_{i=1}^{n} x_i C_t^*(\varepsilon) \tag{4.2a}$$

or

$$C_t^*(\alpha) = \sum_{i=1}^{n} x_i C_t^*(\alpha) \tag{4.2b}$$

Referring to the thoughts about risk adequate capitalization we distinguish between ruin probability and expected ruin height, which is expressed by the lower partial moment zero or one. On basis of the ruin probability, the allocation factors can be determined:[21]

$$x_{it} = \frac{P(S_{it} > E(S_{it}))}{\sum_{j=1}^{n} P(S_{jt} > E(S_{jt}))} \tag{4.3}$$

If the expected policyholder deficit is considered as a risk measure for the determination of the risk adequate capitalization, the expected ruin height can be determined as the average exceeded amount $\mu_+(S_t)$ of the potential loss over its expected value:[22]

$$x_{it} = \frac{\mu_+(S_{it})}{\sum_{j=1}^{n} \mu_+(S_{jt})} \tag{4.4}$$

[20] Therefore the standard deviation can be used as well, see Albrecht 1998.
[21] See Albrecht 1998, p. 250; Cummins 2000, pp. 16; Saita 1999, pp. 100.
[22] See Albrecht 1998, pp. 250; Artzner 1999, pp. 22; Cummins 2000, pp. 17; Singh 2002, pp. 38.

The methods based on shortfalls do not reduce the diversification advantage linearly. But still they are major to the volatility based methods because of their compatibility with preferences. As we can see, both types of methods do not fulfill all formal criteria mentioned above. A dominance of one method over the other cannot be estimated. The choice is clearly dependent on the preferences of the decision maker.

4.3. Approaches based on game-theory

The idea behind game theory it to minimize the maximum discontent of the decision makers in the business units. This is basis for the distribution of the capital that has been saved because of the collectivization-process. The first task is to determine the willingness of the business unit leaders to accept equity capital. From game theory, so called cost-gap-methods have emerged. These methods fix the marginal risk of a business unit as the lower limit for the risk cost distribution. The gap between overall risk costs and the sum of the lower limits is to be distributed in a fair way. The fairness of the allocation method is to be examined by the criteria mentioned above. More pragmatic methods, e.g. the average-method[23] or the Moriarity-method[24] are neither risk adequate nor have they the characteristics of "Strohmann".[25] Risk-adjusted methods assume a volatility based discount from the capital requirements of an isolated business unit. We take a look at the modified marginal cost method, which is developed from the τ-value method.[26]

The lower limit C_{it}^{min} of a business unit i corresponds to the minimum capital requirements, that are caused by any coalition k. It is represented by the minimum difference between the capital requirements with (C_{kt}) and without business unit i $(C_{k \vee it})$ from the amount of all possible coalitions:

$$C_{it}^{min} = \min_{k, i \in k} \{C_{kt} - C_{k \vee it}\} \tag{4.5}$$

[23] See Kinder 1999, p. 162.
[24] See Moriarity 1975, 1976.
[25] See Kinder 1999, pp. 162.
[26] See Tijs/Driessen 1986; Tijs 1987.

However, it will not be enough to allocate equity capital in the amount of the lower limit to each business unit. The capital requirements on company level will exceed this aggregate. More, the difference δC_t that will be allocated is represented by the overall capitalization subtracted with the sum of all lower limits:

$$\delta C_t = C_t - \sum_{i=1}^{n} C_{it}^{min} \tag{4.6}$$

In spite of the lower limit representing the minimum capital allocation and the difference representing the additional capital to be allocated, the upper limit C_{it}^{max} is to be determined as well. It limits the maximum capital requirements of a business unit. The natural maximum can be defined as the individual capital requirements. The capital allocation C_{it}^{*} for each business unit can be defined as the addition of the lower limit and the share of the cost gap.

$$C_{it}^{*} = C_{it}^{min} + \delta C_t \frac{C_{it}^{max} - C_{it}^{min}}{\sum_{j=1}^{n} \left(C_{jt}^{max} - C_{jt}^{min} \right)} \tag{4.8}$$

This modified marginal cost method avoids the problems linked to the τ-value method.[27] In addition, it is sufficient for most requirements except that it is not monotonous.[28] The exactness of methods based on game theory is because of their heuristic character doubtful.

[27] The τ-value approach calculates the lower limit as additional captital requirement, caused by an addition of a business unit. This may lead to the paradoxon, that the upper limit is lower than the lower limit. See Kinder/Steiner/Willinsky 2001.
[28] In detail see Kinder 1999, pp. 190.

4.4. The „Renunciation-Solution“

None of the methods presented so far could be identified dominant in respect to the formal criteria and to the as regard content criteria.[29] But still, the choice of the allocation methods has a major meaning. This can be shown by the following example:

A company consists of three units A, B and C which can be characterized as follows. For reasons of simplicity we examine the lognormal distributed variable of loss S_A, S_B, and S_C for every business unit. The financial distribution of success can be described as $CF_{it} = \pi_{it} - S_{it}$ with a given π_{it}. The premium in each business unit corresponds to the expected value of loss. This is why the expected contribution to success is zero. The capitalization C_{it}^* in each business unit leads to a probability of ruin which is 5% ($UPM(CF_i, C_i) = 0{,}05$ for $i = \{A, B, C\}$). The following table summarizes the mentioned measures of risk.

Business Unit / Parameter	{A}	{B}	{C}
μ	1,0	1,5	1,0
σ	0,25	0,4	0,5
π_{it}	2,80	4,85	3,08
C_{it}	1,30	3,80	3,11
$E(CF_{it})$	0	0	0
$\sigma(CF_{it})$	0,71	2,02	1,64
$LPM_0 = (CF_{it}, C_{it})$	0,05	0,05	0,05

Table 2: Description of the business units

The use of different methods of allocation leads to significantly different results, which are summed up in the following table. Obviously, the choice of the allocation method is of great importance. Because none of the methods dominates in respect to the criteria mentioned earlier, the decomposition of the advantage of collectivity is

[29] For the criteria see pp. 8.

counteracted. Despite this problem of modeling, there are additional problems concerning economic practicability.

	{A}	{B}	{C}
Isolated determination	1,30	3,80	3,11
Variance method	0,34	2,74	1,81
Standard deviation method	0,80	2,26	1,84
Average method	0,20	2, 70	2,01
Moriarity method	0,77	2,27	1,86
Risk adequate discount method (Var)	1,06	1,95	1,89
Risk adequate discount method (STD)	0,77	2,28	1,85
Modified marginal costs method	0,59	2,48	1,82

Table 3: Allocation methods, part I

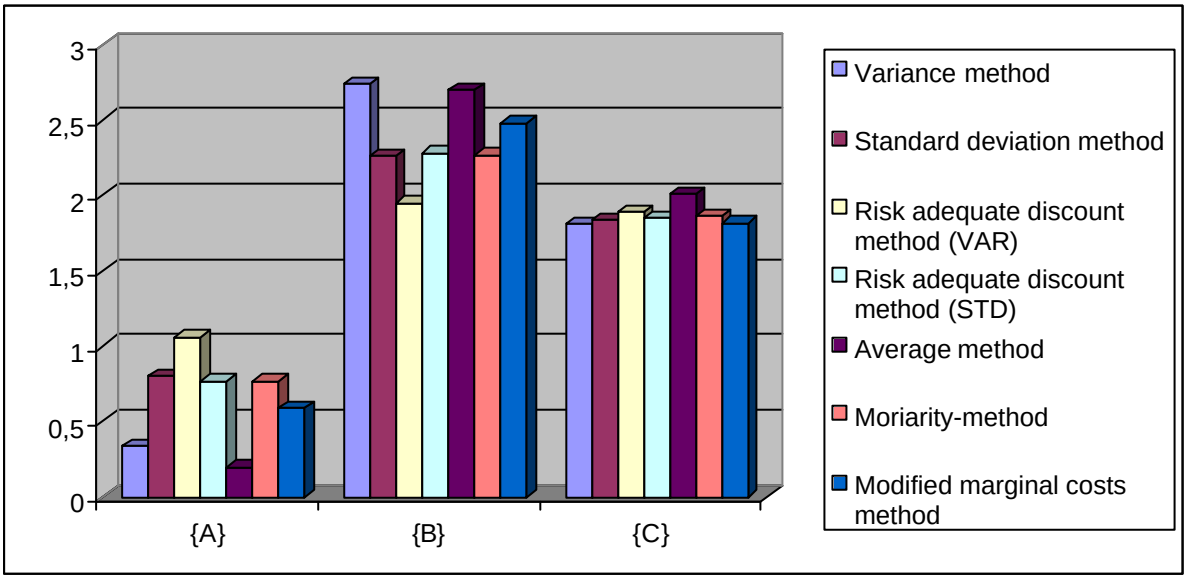

Table 4: Allocation methods, part II

In chapter 2 we discussed how decision makers of business units can improve their performance. In this context we outlined, that these actions have effects both on the heights of the expected performance and on the inherent risk of a business unit. Of course, this has consequences on the expected performance and the risk within the whole company which means that we have consequences on equity capital requirements. Theoretically, every measure taken in an individual business unit leads to a need for reallocation of equity capital within the whole company. Because of the

mass of measures taken in a company, capital allocation is a permanent process. Reasons of practicability tie this process to company specific planning.

One possibility to solve this problem is to neglect any capital allocation on the level of business units, which is consistent with the requirements of performance measurement. The netting of capital costs is done with isolated business units. First, the decision makers of the business units announce their capital requirements without recognition of collectivity effects. The capitalization determines the specific cost of capital of each business unit. By proceeding this way on one hand, the responsibility of the decision maker for the performance of his/her business unit is set clear. On the other hand, the separation of the cost of capital advantage related to the whole company gets obvious.

$$\sum_{i=1}^{n} r^{*} C_{it}(\varepsilon, \alpha) > r^{*} C_{t}^{*}(\varepsilon, \alpha) \tag{4.9}$$

The isolated capital requirements of a business unit is higher than the capital requirements when diversification effects are taken into account. Therefore, the cost of capital for the isolated business unit is higher

$$\sum_{i=1}^{n} r^{*} C_{it}(\varepsilon, \alpha) > \sum_{i=1}^{n} r^{*} C_{it}^{*}(\varepsilon, \alpha) \tag{4.10}$$

Without a change in cash flow, the economic value added without consideration of the advantage of collectives is lower

$$EVA_{it} < EVA_{it}^{*} \tag{4.11}$$

For the decision maker this means that the following demand is harder to fulfill

$$EVA_{it} = E(CF_{it}) - r^{*} C_{it}(\varepsilon, \alpha) \overset{!}{>} 0 \tag{4.12}$$

than with consideration of diversification effects. However, the isolated performance measurement guarantees a clearer responsibility of a decision maker for the

performance of his or her business unit. Therefore this proceeding has high compatibility with the preferences. But there is neither a linear reduction of the overall risk nor a recognition of stochastic dependencies. The formal criteria are only partly fulfilled. Considering criteria of content, an individual but no collective rationality is assumed. Therefore, the solution is not a pareto-optimum. Still, the “Strohmann” characterization is realized as well as monotony and symmetry.[30]

A reduction of capital requirements and cost of capital can be reached by the top management that does the intra-organizational structuring. Looking at the whole company, the advantage concerning cost of capital that results from aggregation of risks from different business units is defined as follows

$$\Delta C_t(\varepsilon,\alpha)r^* = \left(\sum_{i=1}^{n} C_{it}(\varepsilon,\alpha) - C_t^*(\varepsilon,\alpha)\right)r^* \tag{4.13}$$

Next to the cost of capital, the costs for keeping a bonus capital r^*C^{Bonus} have to be allocated to the top management, too. This capital is specific to the company and therefore cannot be covered by single business units. The performance of the whole company has different causes, which are the aggregated contributions of the business units, the advantages of diversification for cost of capital and costs for bonus capital. The optimization is defined as follows

$$\max\left\{\sum_{t=0}^{T}\sum_{i=1}^{n}\frac{E(EVA_{it}) + r^*\left(\Delta C_t(\varepsilon,\alpha) - C_t^{Bonus}\right)}{(1+i)^t}\right\} \tag{4.14}$$

A method based on performance measurement disturbs the possibilities of control because the resulting cash flows are not directly relevant for decision-making. Even business units with a lasting negative cash flow can contribute to the positive diversification effects. It is possible that the disadvantage of negative cash flows can be offset by the diversification advantage. The control of the whole company has to be conducted under consideration of the diversification effect concerning cost of capital.

[30] For the criteria see pp. 8.

5. Conclusion

This paper examines various methods of determination and allocation of a risk-adequate equity capitalization for performance measurement reasons. First, internal models for the determination of a risk-adequate capitalization were presented. Next, these models were compared to external models, e.g. supervision and rating agencies. Even if internal models are more risk-adequate, the external models are of necessary character. Supervisory requirements concerning equity capitalization may not be fallen short of. Ratings are necessary for communication in financial and capital markets, but also important in insurance markets. In this context, especially the recognition of bonus capital leads to different problems. Such influences counterpart the realization of risk-theoretic adequacy. The parallel use of different models requires substantial cost-benefit analysis.

For an isolated performance measurement of individual business units, the diversification effect cannot be allocated, because the business unit decision makers are nor responsible for it. This solution is also positive because the reduction of the advantage of collectivity is highly dependent on the choice of allocation method. Because there is no superior method, the decomposition cannot be conducted without arbitrariness.[31] The performance measurement requires clear responsibilities of the business unit leader for the results. A recognition of diversification effects that are produced on top-management level counterpart this necessity.

We propose to do without the reduction of the advantage of collectives. The top management as its own profit center is responsible for this advantage by its structural management. But this means also that the top management is responsible for the costs that result from keeping bonus capital. The resulting optimization includes these interdependencies. Next to economic advantages, the renunciation solution fulfills most formal criteria and the criteria concerning content.

The control of the whole company requires the allocation of the reduced capital requirements. Here, the contribution of a business unit to the balance of the portfolio is relevant. Business units with a negative cash-flow can still contribute to the

[31] See Schradin 1998, p. 218.

aggregation of risks on company level in a positive way. Of course, also the case where good-performing business units rise the risk level of the company has to be thought of. Considering this background, the renunciation solution is a challenge for performance measurement.

References

Albrecht, Peter (Albrecht 1998): Risikoadjustierte Performancesteuerung in der Schadenversicherung, in: Credit Risk und Value-at-Risk Alternativen, edited by Andreas Oehler, Stuttgart 1998, pp. 229-257

Artzner, Philippe (Artzner 1999): Application of Coherent Risk Measures to Capital Requirements in Insurance, in: North American Actuarial Journal, 1999, Vol. 3, Nr. 2, pp. 11-25

Babbel, David F., Robert Stricker, Irwin T. Vanderhoof (Babbel/Stricker/Vanderhoof 1999): A Performance Measurement System for Insurers, in: Investment Management for Insurers, edited by David F. Babbel and Frank J. Fabozzi, New Hope 1999, pp. 61-75

Barth, Michael M. (Barth 2000): A Comparision of Risk-Based Capital Standards Under the Expected Policyholder Deficit and the Probability of Ruin Approaches, in: The Journal of Risk and Insurance, 2000, Vol. 67, pp. 397-414

Basel Committee on Banking Supervision (Basel Committee on Banking Supervision 2001): The New Basel Capital Accord, http://www.bis.org/publ/bcbsca03.pdf

Bushler, Anatoly, Jason Hanleybrown, Julian Lighton, Robert T. Uhlaner (Bushler et al. 2001): Mutually Assured Survival, in: The McKinsey Quarterly, 2001, pp. 155-163

Butsic, Robert P. (Bustic 1994): Solvency Measurement for Property-Liability Risk-Based Capital Applications, in: The Journal of Risk and Insurance, 1994, Vol. 61, pp. 656-690

Cummins, J. David (Cummins 2000): Allocation of Capital in the Insurance Industry, in: Risk Management and Insurance Review, 2000, Vol. 3, pp. 7-27

Cummins, J. David, Scott E. Harrington, G. Niehaus (Cummins/Harrington/Niehaus 1993): An Economic Overview of Risk-Based Capital Requirements in the Property-Liability Insurance Industry, in: Journal of Insurance Regulation, 1993, Vol. 11, pp. 427-447

Graumann, Matthias, Stephanie Baum (Graumann/Baum 2002): Methoden zur Allokation von Sicherheitskapital, Working Paper, Organisationsseminar, Universität zu Köln 2002

Hille, Christian T., Christoph Burmester, Matthias Otto (Hille/Burmester/Otto 2000): Modelle zur risikoadjustierten Kapitalallokation, in: Die Bank, 2000, pp. 190-195

Hooker, N. D., J. R. Bulmer, S. M. Cooper, P. A. G. Green, P. H. Hinton (Hooker et al. 1996): Risk- Based Capital in General Insurance, in British Actuarial Journal, 1996, Vol. 2, Part II, Nr. 7, pp. 265-323

James, Christopher (James 1996): RAROC Based Capital Budgeting and Performance Evaluation: A Case Study of Bank Capital Allocation, Working Paper 96-40, The Wharton School 1996

Jorion, Philippe (Jorion 2001): Value at Risk, 2nd Ed., New York 2001

Kinder, Christian (Kinder 1999): Interne Leistungsverrechnung in Industriebetrieben und Banken, Köln 1999

Kinder, Christian, Manfred Steiner, Christian Willinsky (Kinder/Steiner/Willinsky 2001): Kapitalallokation und Verrechnung von Risikokapitalkosten in Kreditinstituten, in: Zeitschrift für Betriebswirtschaft, 2001, Vol. 71, pp. 281-300

KPMG (KPMG 2002): Study Into the Methodologies to Assess the Overall Financial Position of an Insurance Undertaking From the Perspective of Prudential Supervision, http://www.kpmg.co.uk/kpmg/uk/image/eus2_report.pdf

Lanfermann, Bettina (Lanfermann1998): Transparenz durch Ratings?, Karlsruhe 1998

Lee, Alice C., J. David Cummins (Lee/Cummins 1998): Alternative Models for Estimating the Cost of Equity Capital for Property/Casualty Insurers, in: Review of Quantitative Finance and Accounting, 1998, Vol. 10, pp. 235-267

Matten, Chris (Matten 1996): Managing Bank Capital, Chichester 1996

Merton, Robert C., André F. Perold (Merton/Perold 1993) : Theory of Risk Capital in Financial Firms, in : Journal of Applied Corporate Finance, 1993, Nr. 6, pp. 16-32

Moriarity, Shane (Moriarity 1975): Another Approach to Allocating Joint Costs. A Comment, in: The Accounting Review, 1975, Vol. 50, pp. 791-795

Moriarity, Shane (Moriarity 1976): Another Approach to Allocating Joint Costs. A Reply, in: The Accounting Review, 1976, Vol. 51, pp. 686-687

Myers, Steward C., James A. Read, Jr. (Myers/Read 2001): Capital Allocation for Insurance Companies, in: The Journal of Risk and Insurance, 2001, Vol. 68, pp. 545-580

The Reactions Standard & Poor's Criteria Handbook 1997 (Reactions 1997), London 1997

Saita, Francesco (Saita 1999): Allocation of Risk Capital in Financial Institutions, in: Financial Management, 1999, Vol. 28, pp. 95-111

Schedlbauer, Thomas, Mark Scully (Schedlbauer/Scully 1997): Ein Vergleich von Versicherungs-Ratingagenturen und –verfahren in den USA, in: Versicherungswirtschaft, 1997, Vol. 52, pp. 664-668

Schierenbeck, Henner (Schierenbeck 2001): Ertragsorientiertes Bankmanagement, 7th Ed., Wiesbaden 2001

Schierenbeck, Henner, Michael Lister (Schierenbeck/Lister 1997): Integrierte Risikomessung und Risikokapitalallokation, in: Die Bank, 1997, pp. 492-499

Schmeiser, Hato, Helmut Gründl (Schmeiser/Gründl 2001): Marktwertorientierte Unternehmens- und Geschäftsbereichssteuerung in Finanzdienstleistungsunternehmen, Discussion Paper in Business, Nr. 17, Humboldt-Univerisät zu Berlin

Schradin, Heinrich R. (Schradin 1997): Solvenzaufsicht in den Vereinigten Staaten von Amerika. Zur Konzeption des Risk Based Capital, in: Zeitschrift für die gesamte Versicherungswissenschaft, 1997, Vol. 86, pp. 269-294

Schradin, Heinrich R. (Schradin 1998): Finanzielle Steuerung der Rückversicherung, Karlsruhe 1998

Schradin, Heinrich R. (Schradin 2001): Risikoadäquate Kapitalallokation im Versicherungskonzern, Working Paper 1/2001 of Institut für Versicherungswissenschaft an der Universität zu Köln, 2001

Schradin, Heinrich R., Ingo Telschow (Schradin/Telschow 1994): Solvabilitätskontrolle in der Schadenversicherung – eine betriebswirtschaftliche Analyse der Risk Based Capital (RBC)-Anforderungen in den Vereinigten Staaten, in: Zeitschrift für die gesamte Versicherungswissenschaft, 1994, Vol. 83, pp. 363-406

Schradin, Heinrich R., Oliver M. Willmes (Schradin/Willmes 2001): Risk and Return in Industrial Insurance, Working Paper 3/2001 of Institut für Versicherungswissenschaft an der Universität zu Köln, 2001

Singh, Manoj K. (Singh 2002): Risk-Based Capital Allocation Using a Coherent Measure of Risk, in: The Journal of Risk Finance, Vol. 3, Nr. 2, pp. 34-45

Standard & Poor's (Standard & Poor's 1999): Insurance Ratings Criteria (Property/Casualty Edition), New York 1999

Stoughton, Neal M., Josef Zechner (Stoughton/Zechner 1999): Optimal Capital Allocation Using RAROC™ and EVA®, working paper available on http://web.gsm.uci.edu/stoughton/working_papers.htm

Stoughton, Neal M., Josef Zechner (Stoughton/Zechner 2000): The Dynamics of Capital Allocation, working paper available on http://web.gsm.uci.edu/stoughton/working_papers.htm

SwissRe (SwissRe 2000): Die Eigenkapitalausstattung der Nichtlebenversicherer im Spannungsfeld von Sicherheit und Renditeanforderungen, Sigma 1/2000, Zürich 2000

Taflin, Erik (Taflin 2000): Equity allocation and portfolio selection in insurance, in: Insurance Mathematics & Economics, 2000, Vol. 27, pp. 65-81

Tijs, Stef H. (Tijs 1987): An Axiomatization of the τ-Value, in: Mathematical Social Science, 1987, Vol. 13, pp. 177-181

Tijs, Stef H., Theo S. H. Driessen (Tijs/Driessen 1986): Game Theory And Cost Allocation Problems, in: Management Science, Vol. 32, pp. 1015-1028

Zimmerman, Jerold L. (Zimmerman 1997): EVA and Divisional Performance Measurement: Capturing Synergies and Other Issues, in: Journal of Applied Corporate Finance, 1997, Vol. 10, pp. 98-109