Market-Consistent Embedded Value in Non-Life Insurance: How to Measure it and Why

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Abstract: The aim of this paper is to transfer the concept of market consistent embedded value (MCEV) from life to non-life insurance. This is an important task since the differences between management techniques used in life and non-life insurance make management at group level very difficult. Our methodology might be a way out of this unfavorable situation. After explaining the idea of MCEV, we derive differences between life and non-life and develop a MCEV model for non-life business. We apply our model framework to a German non-life insurance company to illustrate its usefulness for management purposes. Furthermore, we illustrate how value components can be allocated to different stakeholders, the value implications of varying loss ratios and costs within a sensitivity analysis, and the use MCEV as a performance metric within a value added analysis.

Keywords: Non-Life Insurance, Value Based Management, Embedded Value, Value Added

1. Introduction

In light of the rapidly changing environment in the insurance industry, *value-based management* techniques are becoming increasingly important (see Liebenberg and Hoyt, 2003). The aim of this paper is to provide a valuable addition to this emerging field of research: We develop and illustrate a concept for determining market-consistent embedded value in non-life insurance. We believe that the concept is helpful in overcoming traditional differences in performance measurement of life and non-life insurance business, making our concept a powerful management tool at the insurance-group level.

Generally, life and non-life are the two main business models in the insurance industry, each with their own unique structures of cash flow and with large differences between the two as to the duration of their assets and liabilities. Traditionally, life and non-life are managed as separate entities; in some countries, this separation is required by law (e.g., in Germany and Switzerland). Nevertheless, most large insurers operate as affiliated groups, i.e., different life and non-life entities are pooled in an insurance group and the group managers decide how to allocate resources so as to maximize shareholder value. These management tasks can be successfully achieved only by constant monitoring and transparent performance measurement.

The traditional separation of life and non-life business, however, has resulted in different management techniques for these two types of companies. *Economic value added* (*EVA*) (see Malmi and Ikäheimo, 2003) and *return on risk-adjusted capital* (*RORAC*) (see Nakada et al., 1999) are very popular performance metrics in non-life insurance, whereas the life insurance industry has focused on the so-called embedded value methodology in recent years and developed the concept of *market-consistent embedded value* (*MCEV*) (see European Insurance CFO Forum, 2009a). In the context of value- and risk-based management, the change of MCEV from one calendar year to the next (value added) can be the basis for quantifying performance and risk-based capital. Especially given the theoretical concern that separate optimization of different business units does not necessarily lead to a global optimum at the group level, the use of different performance metrics is very problematic from a group manager's point of view. For example, the different measures are not directly comparable and it is not possible to combine the different concepts in one management tool at the group level.

We provide a way out of this unfavorable situation by arguing that the *MCEV* is a consistent valuation concept not only for life, but also for non-life insurance. The purpose of this paper is thus to transfer the *MCEV* principles from life to non-life insurance. This simple goal, however, becomes quite complicated in light of the large differences between life and non-life insurance. Therefore, in the first step, we consider the specific characteristics of the two businesses, including structure of asset and liabilities as well as the various types of risks and their relevance for life and non-life.[1] After deriving the special characteristics of non-life contracts

[1] A good example is the difference in the duration of contracts. Most life insurance products are multiyear contracts with monthly or yearly premium payments; non-life insurance products typically have a maturity of

and their consequences for embedded value calculation, we develop a mathematical model that reflects this special character as well as the principles underlying the *MCEV* determination. An example based on empirical data from a German non-life insurance company is used to illustrate the concept and its usefulness for management purposes.

The contribution of this paper is to develop a new valuation technique for non-life insurance that is easy to use, simple to interpret, and directly comparable to life insurance. We build on ideas developed in a working group of the German Actuarial Society on market-consistent embedded value in non-life insurance. The paper is thus not only grounded in recent academic literature, but also of high relevance to practitioners and policymakers. Especially in Europe, with the Solvency II regime soon to be effective, European insurers face significant changes in almost all aspects of their business, including, among others, risk management practices and disclosure requirements (see Eling, Gatzert and Schmeiser, 2009), as well as management techniques at the group level. The *MCEV* is also relevant for North American life insurance companies. A survey among chief financial officers showed that embedded value methodologies like *MCEV* are becoming more and more popular (see Towers Perrin, 2008). Embedded value methodologies are thus important valuation concepts and are the basis of performance metrics for value creation in the life insurance industry; our hope is to provide a foundation for their use in non-life insurance.[2]

The rest of this paper is organized as follows. We first describe the concept of embedded value, which originates from the valuation of life insurance companies (Section 2). Then we consider the specific characteristics of life and non-life insurance businesses (Section 3). In Section 4, we develop a mathematical model that reflects this special character of non-life insurance business, as well as the requirements for MCEV determination. In Section 5, the concept is applied to a German non-life insurance company to illustrate its usefulness. Section 6 concludes.

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one year. A substantial number of these contracts, however, are automatically renewed and an appropriate valuation of this mechanism must be found to derive the factual value of the in-force business.

2 Despite the growing policy interest in embedded value, there has been limited academic attention paid to this methodology. Our hope is thus also to encourage further discussion on this topic in academia.

2. Idea of Market-Consistent Embedded Value

The idea of embedded value calculation originates in the valuation literature and can be traced back to Anderson (1959). Put simply, embedded value estimates the value of a life insurance company by taking into account future cash flows from existing insurance contracts. It is closely related to discounted cash-flow-based valuation techniques.[3] The embedded value itself is thus not a performance measure, but a valuation technique. However, the concept of embedded value might be a promising basis for developing a performance metrics. For this purpose, the embedded value in t=0 and t=1 is compared (so-called value added analysis) and the main drivers for the change of embedded value are identified.

Embedded value is achieving new significance and international attention due to new accounting and regulatory rules, especially the International Financial Reporting Standards (IFRS) and Solvency II (see Olivieria and Pitacco, 2008; De Mey, 2009; Eling and Toplek, 2009; Klein and Wang, 2009). Under both these regimes, insurance business is to be evaluated based on market values, which is an especially new idea for many European insurers, which have traditionally been founded on a conservative/prudent accounting philosophy based on historical values rather than on market values (see Post et al., 2007). Accordingly, many different proposals and principles have been developed, all with different assumptions and methods for addressing the problem.

To combine these different streams of discussion and develop a standard for embedded value calculation, the chief financial officers of 20 major European insurance companies created a discussion group called the CFO Forum. Focusing on consistency and transparency of embedded value reporting, the CFO Forum published the European Embedded Value (EEV) Principles in May 2004 (see European Insurance CFO Forum, 2004). More recently, in re-

[3] More precisely, embedded value can be defined as an insurance-specific application of discounted cash flow techniques as both rely on a projection of future cash flows. An important difference between discounted cash flow techniques and embedded value, however, is that embedded value determines the value of present business only and neglects the value of future new business. Thus, only a closed fund consideration is made, without any additional assumptions about future new business. The main reason for this is that incorporating future new business gives rise to many degrees of freedom and reduces comparability across insurers.

sponse to a general trend toward market-consistent valuation (see Sheldon and Smith, 2004), the CFO Forum launched the Market Consistent Embedded Value Principles (MCEV) (see European Insurance CFO Forum, 2009a), a further development of the EEV principles. The use of these embedded value guidelines will become compulsory for financial reporting by the CFO Forum members.[4] The 17 MCEV principles serve as a general framework for embedded value calculations by life insurers. The MCEV is defined as “a measure of the consolidated value of shareholders’ interests in the covered business” (MCEV Principle 1) (see European Insurance CFO Forum, 2009a). Thus, covered business needs to be clearly identified and disclosed (Principle 2), and, in general, “covered business” encompasses both short- and long-term life insurance business.

There are three main sources of value in a life insurance company: (1) the net asset value, (2) the present value of profits from in-force business, and (3) the present value of profits from future sales. The MCEV is calculated by adding the net asset value and the present value of profits from in-force business, i.e., (1) + (2); adding to this the value of future sales (i.e., (3)), would be called appraisal value (see, e.g., Risk Management Metrics Subgroup, 2001).

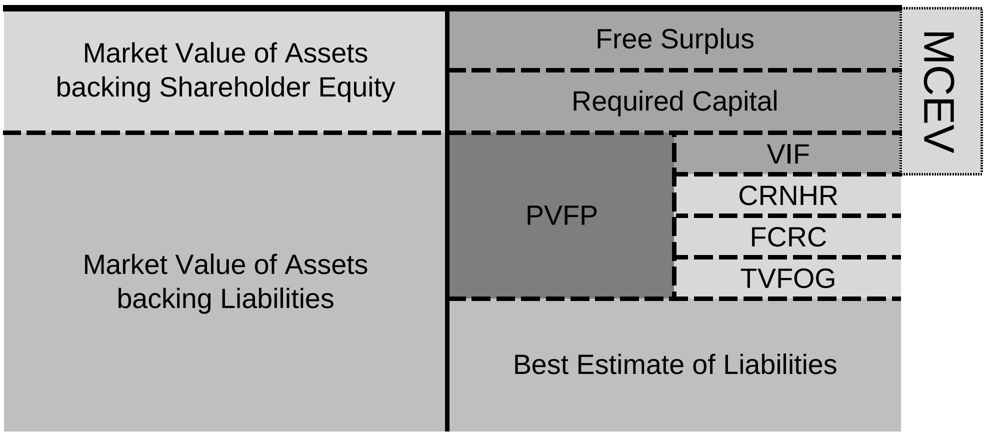

Figure 1: MCEV Elements

4 In the light of the recent financial crisis, the CFO Forum decided to conduct a review of the MCEV principles and to defer mandatory reporting until 2011; the particular areas under review include implied volatilities, the cost of nonhedgeable risks, the use of swap rates, and the effect of liquidity premia. While implied volatilities do not play an essential role in non-life insurance business, the remaining issues might have some impact on MCEV calculations in non-life insurance. However, they mostly refer to parameterization issues and do not affect the general valuation framework. Overall, these recent discussions are related to IFRS 4 on fair value/high volatility oriented accounting approaches versus amortized cost/low volatility oriented accounting approaches (see Post et al., 2007) and emphasize the high relevance of MCEV in practice.

Figure 1 illustrates the MCEV elements as described in the European Insurance CFO Forum (2009a). According to Principle 3, the market-consistent embedded value is the present value of shareholders' interests in the earnings distributable from assets allocated to the covered business. Thus, sufficient allowance for the aggregate risk must be made. The MCEV consists of three elements: free surplus (FS), required capital (RC), and the value of the in-force business (VIF).

Assets allocated to the covered business are split between assets backing shareholder equity and assets backing liabilities, where liabilities are valuated based on local regulatory requirements. The market value of the assets backing shareholder equity is called shareholders' net worth and is the sum of free surplus (FS) and required capital (RC) (see European Insurance CFO Forum, 2009a).

The *required capital* (Principle 5) is that portion of the assets backing shareholder equity that due to regulatory requirements cannot be distributed to them. The amount of required capital must comply with local regulatory requirements and other legal restrictions, but should also take into account internal objectives, such as internal risk assessment or target credit rating. Correspondingly, the *free surplus* (Principle 4) is that portion of the assets backing shareholder equity that is not needed to support the in-force covered business at the valuation date and that has no restrictions on its distribution to shareholders.

The major challenge for embedded value calculations is to find a best estimate of the present value of the profits from in-force business and for the assets backing the associated liabilities. The present value of profits overestimates the true value of the in-force business, because investors have to bear frictional costs and because insurance contracts typically include a number of options and guarantees. These are all costs that investors would not have to bear by directly investing in the capital market and for that reason the present value of the future profits need to be adjusted so as to arrive at a market-consistent value. The value of the in-force business (VIF) is thus estimated by considering four components (Principle 6): the *present* *value of future profits* (PVFP), which is reduced by the *time value of financial options and guarantees* (TVFOG), the *frictional costs of required capital* (FCRC), and the *cost of residual nonhedgeable risks* (CRNHR).

The *present value of future profits* reflects the projected shareholder cash flows from the in-force covered business and the assets backing the associated liabilities. Profits are determined after taxation and net of reinsurance. Furthermore, by means of a stochastic model for the financial market, allowance must be made in the MCEV for the *time value of financial options and guarantees* (Principle 7). These two components show that the CFO Forum demands mark-to-market valuation (Principle 3), i.e., insurance liabilities must be valued as though they are traded assets. Since insurance liabilities usually are not traded on an open market, assets cash flows that most closely resemble the insurance cash flows are used. For this purpose, economic assumptions are set out in Principles 12 to 16. In particular, according to Principle 13, for those cash flows that vary linearly with, or are even independent of, market movements, both investment returns and discount rates are determined in a deterministic framework. In particular, this so-called certainty-equivalent approach assumes that all assets earn the risk-free reference rate and all cash flows are discounted using this reference rate. Only when cash flows do not vary linearly with market movements, e.g., cash flows reflect financial options and guarantees, stochastic models are necessary for a proper market-consistent valuation (Principle 13). As a reference rate, the European CFO Forum prescribes use of the swap yield curve appropriate to the currency of the cash flows (Principle 14).

Additionally, allowance must be made for the *frictional costs of required capital* (Principle 8). Frictional costs occur through taxation and investment costs on the assets backing required capital and should be independent of the nonhedgeable risk allowance. Finally, *cost of residual nonhedgeable risks* (Principle 9) must be considered when calculating the value of in-force business. This cost can be divided into nonhedgeable financial risks and nonhedgeable nonfinancial risks.[5] A suitable approach for determining the cost of residual nonhedgeable risks must be employed, one that provides sufficient disclosure to enable a comparison to a cost of capital methodology (see Exley and Smith, 2006).[6]

The value of the in-force covered business can be divided into new business and existing business (Principle 10). New business is comprised of all contracts written within the last 12 months. Existing business comprises all contracts written more than 12 months ago. The value of future new business is excluded from the MCEV. However, the VIF should anticipate renewal of in-force business. More specifically, renewals should include expected levels of contractual renewal in accordance with policy conditions, noncontractual variations in premiums where these are reasonably predictable, or recurrent single premiums where the level of premium is predefined and reasonably predictable.

From a modeling perspective, the determination of VIF can be broken down into three steps (see Table 1). The first step is to develop a mathematical model of the environment, i.e., the capital market (e.g., a stochastic process for interest rates, such as the Vasicek (1977) model), the mortality (e.g., a stochastic process for mortality, such as the Cairns, Blake and Dowd (2006) model), and other external factors (e.g., cancellation behavior[7] and exercise of other options). Building on the stochastic environment model, the second step is to model the cash flows from the insurance contracts, i.e., the cash inflows and cash outflows. Additionally, firm-specific factors, such as costs and taxes, have to be taken into account. The residual of cash inflow minus cash outflow (taking into account costs and taxes) is what is left for the shareholders and constitutes the present value of future profits. Note that according to the MCEV definition (Principle 3), the focus is on distributable earnings, i.e., the present value of

5 Nonhedgeable financial risks result from illiquid or nonexistent markets where the financial assumptions used are not based on sufficiently credible data. Non financial risks include, mortality, longevity, morbidity, persistency, expense and operational risks. See European Insurance CFO Forum, 2009b.

6 Note that the MCEV does not reflect the shareholders' default put option that results from their limited liability. More precisely, it is implicitly assumed that the shareholders will make up any deficit arising in the future, with no upper limit on the amount of such deficit.

7 There is no standard terminology in the literature for the event of premature termination of insurance contracts. Alternative terms are cancellation, surrender, and lapse. In this paper, we use the term "cancellation."

future profits reflects statutory profits under local GAAP regulations. The third and final step is to reduce the present value of future profits by the frictional and other costs (TVFOG, CRNHR) that investors have to bear compared to direct investment on the capital market.

Step	Procedure
1. Modeling the environment (external)	a) Modeling the capital market b) Modeling biometric risks c) Modeling cancellation behavior and implicit options
2. Modeling the insurance company (internal)	a) Based on Step 1,modeling the cash inflow and cash outflow for existing insurance contracts, considering capital markets, cancellation behavior, and biometric risks b) Allow for company-specific factors such as costs and taxes c) The remainder goes to the shareholders
3. Determining value of the in-force business	Reduce the present value of future profits (PVFP) by - the time value of financial options and guarantees (TVFOG) - the frictional costs of required capital (FCRC) - the cost of residual nonhedgeable risks (CRNHR)

Table 1: Determination of the Value of the In-Force Business

The MCEV methodology is used to determine the value of short- and long-term life insurance business. Additionally, the CFO Forum also defines a *group MCEV*, stating that this is a measure of the consolidated value of shareholder interests in covered and noncovered business at the group level (Principle 17).[8] The CFO Forum proposes that the noncovered business should be valued at the unadjusted IFRS net asset value. The group MCEV, according to the CFO Forum, is thus the sum of the covered business (valued according to the MCEV methodology) and the noncovered business (valued according to IFRS net asset value). However, adjustments may be necessary to ensure consistency between values assigned to covered and noncovered business.

In our opinion, combining market-consistent values with IFRS balance sheet values does not seem a consistent or appropriate way to calculate embedded values at the group level. Instead extending the MCEV principles from covered (life insurance) business to noncovered (non-life insurance) business is a feasible and much more consistent method. The aim of this paper is thus to transfer the embedded value methodology from life to non-life insurance.

[8] As mentioned, “covered business” in general encompasses short- and long-term life insurance business. The “non-covered” business thus in general means non-life business.

Thus, covered business needs to be clearly identified and disclosed (Principle 2), and, in general, "covered business" encompasses both short- and long-term life insurance business.

3. Differences between Life and Non-Life and Consequences for MCEV Determination

In this section, we outline the main differences between life and non-life insurance and derive the consequences of these differences for modeling MCEV. Table 2 sets out a comparison of life and non-life insurers on a number of broad criteria, including contract nature, reserve estimation, and balance sheet structure.

Criteria	**Life**	**Non-Life**
Contract duration	many years	usually one year, but renewal on a rolling basis
Main type of services	intermediation (saving and dis-saving)	risk pooling
Secondary services	risk pooling, financial services	intermediation, financial services
Structure of assets	long-term-oriented portfolio	short-term-oriented portfolio
Structure of liabilities	limited degree of uncertainty with regard to claim payments and reserves (to the extent this is linked to underwriting risks)	high degree of uncertainty with regard to claim payments and reserves, especially in lines exposed to catastrophe risk
Duration of liabilities	long	short-tail lines and long-tail lines
Use of reinsurance	limited use	substantial use, depending on the line
Surrender value	yes	usually no
Cancellation behavior	analyzed in literature	not analyzed in literature
Reserves	policy reserves, reserve for premium refund (in some countries)	claim reserves, equalization reserves (in some countries)
Financial options and guarantees	essential part	nonessential part
Diversification between lines of business	typically very low, not many LoBs	typically very high, many LoBs (many different types of contracts)
Conclusions	**Life**	**Non-Life**
Dynamic of the balance sheet mainly comes from…	assets & liabilities	mainly liabilities
Relevance for modeling….		
- Capital markets	++	+
- Catastrophes	+	++
- Biometric risk	+	no relevance
- Options & guarantees	++	no relevance
- Underwriting risk	+	++
- Market risk	++	+
Main challenges for MCEV determination	capital market conditions (interest rates), biometric risk, implicit options, cancellation	claim number and severity, modeling of catastrophes, renewal decision

Table 2: A Comparison of Life and Non-Life Insurance

Determining MCEV is based on a present value calculus, i.e., we calculate the present value of future cash flows. This is a complicated task even in the case of manufacturing (with given order book and production capacity), but can be even more so for insurance companies in large part due to the high uncertainty of future cash flows. The uncertainty is inherent in both the inflow, for example, premiums and returns from the capital market, as well as in the outflow, for example, claim payments and operating costs. In this context, substantial differences can be identified between life and non-life insurance, especially in terms of operations, investment activities, duration of liabilities, and vulnerabilities (see Brockett et al., 1994). The insurers' liabilities as well as the structure of assets depend on the line of business with respect to duration, degree of risk, and risk-determining factors.

Life insurance is a long-term business with a long planning horizon. Given the saving and dissaving process in many contracts, the intermediation component is the most important service provided by life insurers (for different types of services provided by insurance companies, see, e.g., Cummins et al., 2004; Jeng and Lai, 2005). Present values are discounted future cash flows, so the longer the time horizon, the more important the interest rate component. For this reason, interest rates as well as product options embedded in life insurance contracts (such as minimum interest rate guarantees) are of central concern for life insurers. Traditionally, life insurers profited by insureds' adverse exercise behavior with regard to the numerous product options, such as cancellation of the contract. However, recent research has shown the substantial risk potential of these embedded options (see, e.g., Gatzert and Kling, 2007; Gatzert and Schmeiser, 2008), which is why these need to be quantified when calculating MCEV and risk-based capital for life insurers (see, e.g., Plat and Pelser, 2009). Furthermore, the long-term nature of life insurance products results in a robust structure of liabilities and makes it even more important that there are rules for value-based management, since decision making has an impact long into the future.

Non-life insurance is much more short-term oriented than life insurance although there are also long tail lines of business with substantial time periods between premium and claim payments. The duration is about two years for short tail business such as property insurance where claims are usually made during the term of the policy or shortly after the policy has expired. In long tail lines such as third party liability or motor third party liability the duration can be about six to seven years (see CEIOPS, 2008). While life insurer are said to function as “financial intermediaries”, the main type of services provided by non-life insurers is risk pooling (see Chen and Wong, 2004). Claim distributions are much more volatile than benefits to life insurance policyholders, especially in lines of businesses that are exposed to catastrophes. Modeling of catastrophes is thus an important issue in non-life, while product options in contracts are hardly relevant. Although the contracts are set up for one year, the yearly policy renewal is very common. For life insurance, cancellation and embedded options have been broadly analyzed in literature in recent years, while we do not know as much about the premium renewal process in non-life insurance. Moreover, the structure of liabilities in non-life is characterized by a very high fluctuation due to a short-term orientation within non-life insurance products.

The drivers affecting the cash outflow, i.e., the benefits paid to policyholders, are very different between life and non-life. In life insurance, the benefits to policyholders mainly depend on biometric risks, investment returns, and cancellation of the policy; in non-life, a payment is linked to a concrete claim event and thus depends on the distribution of the number and severity of claims. Especially in lines of business that are exposed to catastrophes, underwriting risk thus exhibits a significantly higher dynamic and uncertainty in non-life insurance compared to life insurance. A good example is storm insurance, which typically has a very low number of claims in most years. However, in some years, storms result in a high number of claims so that storm insurers need to build up adequate reserves in good years so as to be able to pay claims in big storm years. Many countries such as Germany use a special kind of reserve called equalization reserves for exactly this purpose. Compared to non-life, life insurers have rather precise estimates of mortality rates (mortality tables) so that annual cash flow fluctuations are less extreme. We can thus conclude that market risk is the most important type of risk for life insurers (as compared to underwriting, liquidity, or other types of risk). In non-life, especially for portfolios mainly based on catastrophe risk, underwriting risk is often more important than market risk.

The policies in force give rise to potential liabilities for which actuarially calculated reserves must be set aside. In life insurance, it is common to set up one single policy reserve. Additionally, some countries have legal rules for surplus participation, resulting in a reserve for premium refunds. In non-life, as mentioned some countries differentiate between the claim reserve and the equalization reserve (e.g., Germany, Switzerland). In these countries, the claim reserve is calculated according to the same principles as the policy reserve but the countries also allow for an equalization reserve to compensate fluctuations in loss ratios over time. The idea here is that especially in those lines of business with significant catastrophes, years with low claim costs act as reserves for paying out in years with higher claim costs. We will account for these special characteristics in our modeling approach.

The main differences between modeling VIF in life and non-life can now be derived. Table 3 is structured like Table 1 and illustrates that there are three main issues to be considered when modeling non-life instead of life:

(1) There are no periodic premium payments in non-life over several years, whereas this is common in life insurance. This is problematic in the context of MCEV when it comes to distinguishing between existing business and renewal business. According to MCEV Principle 10.2, the value of the in-force business should anticipate *renewal* of in-force business, including any *reasonably predictable* variations in the level of *renewal* premiums but excluding any value relating to future new business. From this wording, we conclude that a reasonable renewal assumption is necessary when modeling MCEV in non-life.

(2) The model of biometric risks needs to be replaced by a model for claims development.

(3) The model for cancellation in life insurance corresponds to a model for renewal in non-life insurance. Option exercise does not play an important role in non-life and as a simplified assumption can be ignored.

Step	Life	Non-Life
1. Modeling the environment (external)	a) Modeling the capital market b) Modeling biometric risks c) Modeling cancellation behavior and implicit options	a) Modeling the capital market b) Modeling claims (instead of biometric risks) c) Modeling renewals (instead of cancellation behavior; implicit options are not relevant)
2. Modeling the insurance company (internal)	a) Based on Step 1, modeling the cash inflow and cash outflow for existing insurance contracts considering capital markets, cancellation behavior, and biometric risks b) Allowing for company-specific factors, such as costs and taxes c) The remainder goes to the shareholders	a) Based on Step 1, modeling the cash inflow and cash outflow for existing insurance contracts considering capital markets, renewals, and claim statistics b) Allowing for company-specific factors, such as costs and taxes c) The remainder goes to the shareholders
3. Determining the value of the in-force business	Reducing the present value of future profits (PVFP) by - the time value of financial options and guarantees (TVFOG) - the frictional costs of required capital (FCRC) - the cost of residual nonhedgeable risks (CRNHR)	Reducing the present value of future profits (PVFP) by - the time value of financial options and guarantees (TVFOG) - the frictional costs of required capital (FCRC) - the cost of residual nonhedgeable risks (CRNHR)

Table 3: Main Modeling Differences between Life and Non-Life

Overall, Table 3 demonstrates that determining VIF in non-life insurance is not too different from doing so for life insurance. For instance, the difference between a cancellation decision in life and a renewal decision in non-life is only a minor one from an economic point of view. Taking liability insurance and a classic life insurance policy with regular premium payments as examples, in both cases the customer needs to actively terminate the contract. If the customer does nothing, however, the contract will continue.

4. Modeling of MCEV in Non-Life

We now develop a mathematical model that reflects the differences between life and non-life insurance business and allows us to determine the MCEV of a non-life company. We consider a projection horizon of T years with $t = 1, \dots, T$ and assume a complete settlement of our insurance business in year T. We illustrate our model using German local GAAP ("Handelsgesetzbuch") as a local statutory basis, but our calculations could be based on any local GAAP. Since many details, however, refer to special German rules and characteristics, we only introduce the idea of the model in the paper and refer to the Appendix for all modeling specifics. In the interests of simplifying the model, we also ignore claims inflation and the use of reinsurance.

Our starting point is the statutory balance sheet at $t = 0$ (see Figure 2). The main balance sheet positions on the liability side are shareholder equity (SE_0), equalization reserves (ER_0), and claim reserves (CR_0).[9] Assets are proportionally split between those assets backing shareholder equity (BV_0^{abse}) and assets backing liabilities (BV_0^{abl}).

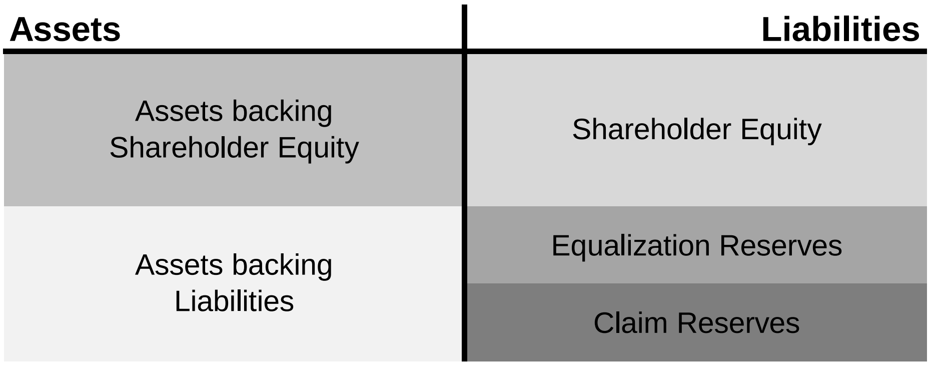

Figure 2: Statutory Balance Sheet

The risk-free yield curve at $t = 0$ is given by predefined swap rates. Both investment returns (forward rates, fr_t) and discount rates (dr_t) are derived from this yield curve (for details, see Appendix A1). To derive the MCEV, we first determine the *(1) present value of future profits* and the *(2) required capital*. In a second step, we evaluate the *(3) frictional costs* and the *(4) costs of residual and nonhedgeable risks*. Finally, *(5) free surplus* is determined.[10]

(1) Present Value of Future Profits

The present value of future profits (PVFP) is the sum of the discounted net income NI_t:

$$PVFP = \sum_{t=1}^{T} NI_t * dr_t. \tag{1}$$

The annual net income consists of earnings before taxes less taxes paid ($NI_t = EBT_t \cdot (1 - tr)$). Earnings before taxes can be calculated by adding the technical result (T_t) and the investment result (I_t) at the end of time period t ($t \in 1, \dots, T$), i.e., $EBT_t = T_t + I_t$.

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9 According to German local GAAP, claim reserves are based on a separate, prudent and conservative valuation, which means that claim reserves under German local GAAP usually exceed best estimate claim reserves. Furthermore, equalization reserves are set up. The German local GAAP is thus an example of the low volatility oriented accounting approaches, in contrast to the fair value accounting approaches adopted in the United Kingdom and the United States. See Post et al. (2007) for more details on accounting differences and Maurer/Somova (2007) for more details on the German insurance industry. For example, there are still restrictions in asset allocations with regard to equity, hedge funds, and other risky investments. No guarantee fund exists in non-life, but there is an industry sponsored guarantee fund in life insurance.

10 Unlike life insurance, non-life insurance contracts have no substantial options and guarantees. We thus set the time value of financial options and guarantees to zero.

The technical result is calculated as gross premiums earned (GPE_t) minus changes in claim reserves ($\Delta CR_t = CR_t - CR_{t-1}$) minus changes in equalization reserves ($\Delta ER_t = ER_t - ER_{t-1}$). We also deduct claim payments (CP_t), acquisition costs (AC_t), claim settlement costs (CSC_t), and overhead costs (OC_t); for a detailed description of each component, see Appendix A2. The technical result is then given as $T_t = GPE_t - \Delta CR_t - \Delta ER_t - CP_t - AC_t - CSC_t - OC_t$.

The investment result is the investment income under local GAAP less the associated investment cost. Under German local GAAP, the book value of assets may differ from the market value of assets and there is some management discretion regarding the realization of gains and losses on assets. In general, there are unrealized gains and losses (*ugl*), which correspond to the difference between the market value and the book value of assets. To determine the investment result it is therefore necessary to project both book value and market value of the assets backing liabilities (taking into account cash flows related to the insurance contracts and investment cost, as well as funding requirements). As a simplified management rule, we assume that the amount of *ugl* (as percentage of the book value of assets) remains constant over the entire projected horizon. For details on the calculation of the investment result, we refer to Appendix A3.

(2) Required Capital

To calculate the required capital we consider the European Union solvency regulations (Solvency I and Solvency II). We therefore take the maximum of $SCR\ I$, determined according to Solvency I requirements, and $SCR\ II$, determined according to the rules currently planned for Solvency II; for a detailed description of each component, see Appendix A4:

$$RC = Max(SCR\ I; SCR\ II) \tag{2}$$

(3) Frictional Costs

FCRC reflects the impact of nondistributable capital (e.g., due to regulatory restrictions) on shareholder equity value. According to MCEV Principle 8, frictional costs should reflect investment costs and taxation on assets backing required capital. Thus, required capital must be projected appropriately over the lifetime (for details on the projection mechanism, see Appendix A4). To derive the FCRC, we need to take into account the net income on the assets backing required capital ($NIRC_t$) and the release of required capital over the projected horizon ($\Delta RQ_t = RQ_t - RQ_{t-1}$). The present value of these cash flows is then compared to the required capital at t=0:

$$FCRC = RQ_0 - \sum_{t=1}^{T}(NIRC_t - \Delta RQ_t) * dr_t \quad (3)$$

The net income on required capital can be determined by considering the forward rate, investment cost rate, tax rate, and discount rate, i.e., $NIRC_t = RQ_{t-1} * (fr_t - icr) * (1 - tr)$ or alternatively $FCRC = \sum_{t=1}^{T} RQ_{t-1} * (icr + tr * (fr_t - icr_t)) * dr_t$. Note that FCRC is zero if both investment costs (*icr*) and tax rate (*tr*) are equal to zero.

(4) Cost of Residual Nonhedgeable Risks

The cost of residual nonhedgeable risks ($CRNHR$) can be derived using a cost-of-capital approach similar to the risk-margin approach under Solvency II (see European Insurance CFO Forum, 2009a). The internal cost of capital rate ($cocr$) is thus multiplied by $SCR\ II$ at valuation date t to determine the cost of capital, which is then discounted to t=0:

$$CRNHR = \sum_{t=1}^{T}(SCR\ II_t * cocr * dr_t) \quad (4)$$

(5) Free Surplus

The insurance company's free surplus capital (FS) consists of the difference between the market value of assets backing shareholder equity (MV_0^{abse}) and the required capital (RC). The market value of assets backing shareholder equity is derived by considering the unrealized gains and losses (*ugl*), i.e., $MV_0^{abse} = BV_0^{abse} * (1 + ugl)$:

$$FS = MV_0^{abse} - RC \quad (5)$$

5. Application for a German non-life insurer

Model Calibration

To illustrate our framework, we now apply the MCEV concept to a German non-life insurance company. All figures and numbers are based on an insurance company used by the German Actuarial Society Working Group on Internal Models (see DAV-Arbeitsgruppe Interne Modelle, 2008). Although this is a fictitious company, model parameters are chosen to realistically reflect a company from the German market. For our applications we use parameters set out in the Appendix B in Table B1, patterns set out in Table B2, and revenue segments set out in Table B3. As a simplifying assumption, we consider only one line of business—third-party liability motor insurance. We start at a valuation date of December 31, 2008, yielding the statutory balance sheet as shown in Figure 3.

Assets		**Liabilities**	
Assets backing Shareholder Equity € 48,236		Shareholder Equity € 48,236	
Assets backing Liabilities € 187,883		Equalization Reserves € 33,932	
		Claim Reserves € 153,951	
Total	**€ 236,119**	**Total**	**€ 236,119**

Figure 3: Statutory Balance Sheet for the Application

Determination of MCEV

Figure 4 sets out two different scenarios for MCEV calculations. In the first, we determine the value of the in-force business without renewals; in the second, we estimate the value of in-force business making a reasonable assumption with regard to renewals.[11] On left side of Figure 4 (Scenario 1), the cancellation rate is 100% (i.e., renewal rate 0%). We thus do not con-

[11] Scenario 1 provides a lower bound for the in-force business; Scenario 2 (cancellation rate less than 100%) provides a more realistic estimator of the market-consistent embedded value. Note that depending on the profitability of the renewal contracts, Scenario 1 does not necessarily provide a lower bound. However, in practical applications, we will see that it should be a lower bound.

sider any renewals within the next few years, but only settle the existing business. This settlement process yields a total MCEV of € 110,735, where free surplus is € 26,720, required capital is € 22,481, and the value of in-force business is € 61,534.

Scenario 1

Free Surplus € 26,720	Required Capital € 22,481	Value of in-force Business € 61,534
Market Consistent Embedded Value € 110,735		

Scenario 2

Free Surplus € 18,913	Required Capital € 30,288	Value of in-force Business € 88,704
Market Consistent Embedded Value € 137,905		

Figure 4: MCEV for a Cancellation Rate of 100% and 13%

The right side of Figure 4 (Scenario 2) shows the results for a cancellation rate of 13% (i.e., renewal rate 87%). This scenario thus takes into account the fact that a substantial number of insurance contracts are automatically renewed each year and is a more realistic picture of the insurance company's value. In Scenario 2, MCEV increases to € 137,905, the free surplus decreases by € 7,807 (with a corresponding increase of the required capital), and the *VIF* increases by € 27,170.

Economic Balance Sheet

The MCEV can serve as a basis for setting up an economic balance sheet. This kind of economic framework can be a valuable aid in understanding what creates and what destroys value (see O'Keeffe et al., 2005, p. 452). In contrast to the statutory balance sheet, in the economic balance sheet we consider market values and make allowance for all future cash flows out of our insurance company, given the assumption of a complete settlement of our insurance business in year T. In Figure 5, we again consider two different scenarios for MCEV calculation, one without renewals (cancellation rate of 100%) and one with renewals (cancellation rate of 13%).

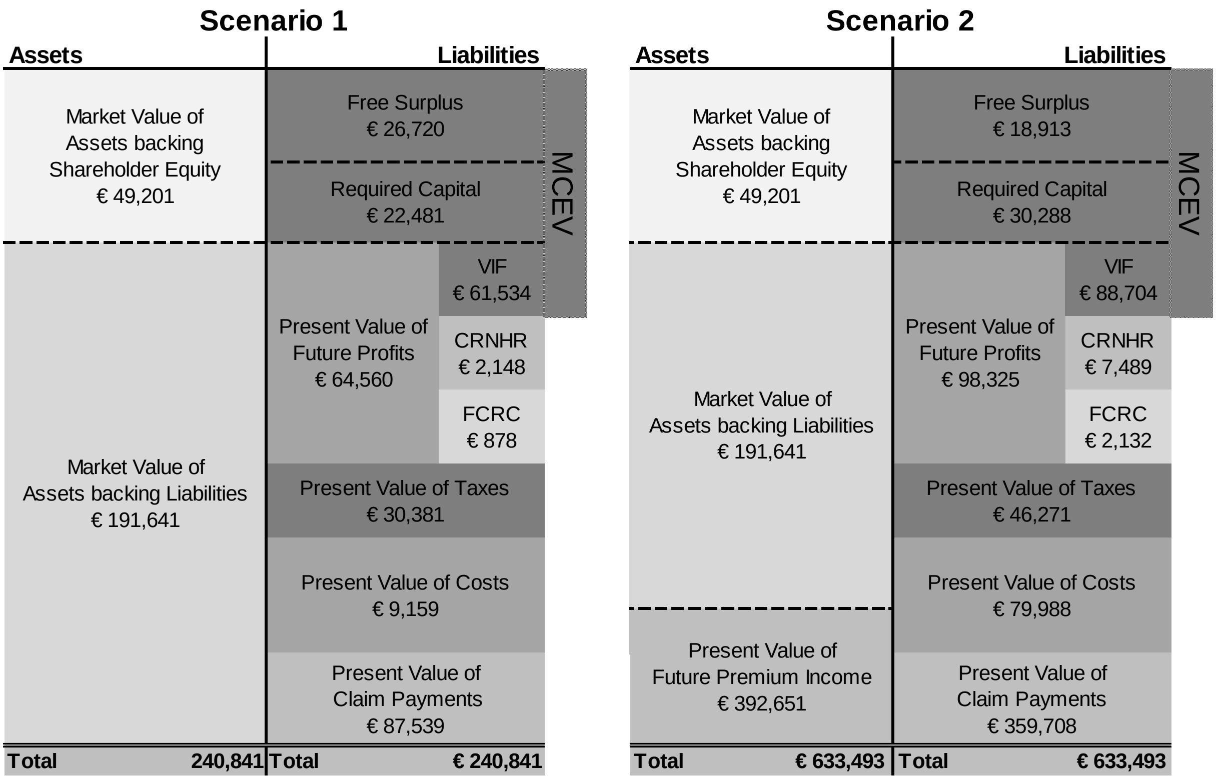

Figure 5: Economic Balance Sheet (Without and With Renewals)

In Scenario 1, the total balance sheet yields an amount of € 240,841. In Scenario 2, the total is € 633,493. This much larger amount for Scenario 2 is because, in addition to the market value of assets, we also consider the present value of future premiums (€ 392,651) as we are taking renewals into account.

We use the economic balance sheet to derive a capital appropriation in Figure 6, which shows all stakeholders that receive cash flows from the insurance company. In addition to free surplus, required capital, and the present value of future profits, frictional costs of required capital (FCRC), reflecting investment costs and taxation, must be taken into account when considering the required capital. FCRC would be assigned to the insurance company's staff (internal beneficiaries) and the tax office (external beneficiaries) and thus subtract from the cash making up required capital, meaning that required capital would have to be decreased by these amounts.[12]

[12] Note that this capital appropriation does not include costs of residual and nonhedgeable risk (CRNHR) since there is no cash outflow related to this position.

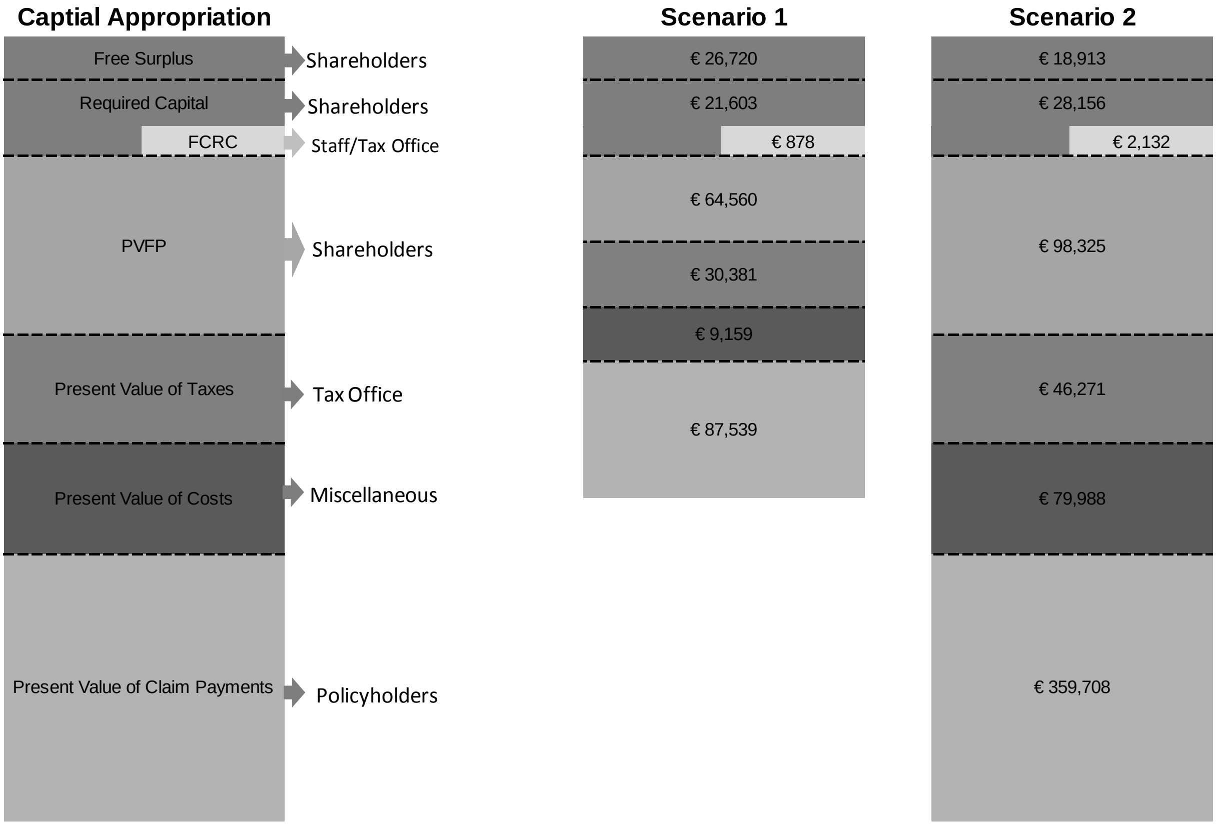

Figure 6: Capital Appropriation (Without and With Renewals)

Sensitivity Analysis

We analyze the robustness of the model and the value implications of different model assumptions with a sensitivity analysis. Here, we only illustrate two simple examples with varying loss ratios, cancellation rates, and acquisition costs. An extended sensitivity analysis based on simulation is available upon request.

First, we consider different parameter assumptions for the loss ratio and for the cancellation rate in Figure 7. The higher the loss ratio, the lower the MCEV, as more funds are paid out to policyholders. There is an interesting interaction between the cancellation rate and the loss ratio. With a low loss ratio, a reduction of cancellation rates increases the MCEV, but with a very high loss ratio, an increase in cancellation rates can be value enhancing. In this situation, the business underwritten is not profitable. In our example, the turning point would be a loss ratio of approximately 80%. For a very high loss ratio of 110% and a cancellation rate of 13%, we would still have a positive MCEV in the amount of € 26,101. This is due to the fact that a negative value of in-force covered business of € 23,099 is balanced out by a positive free surplus and required capital.

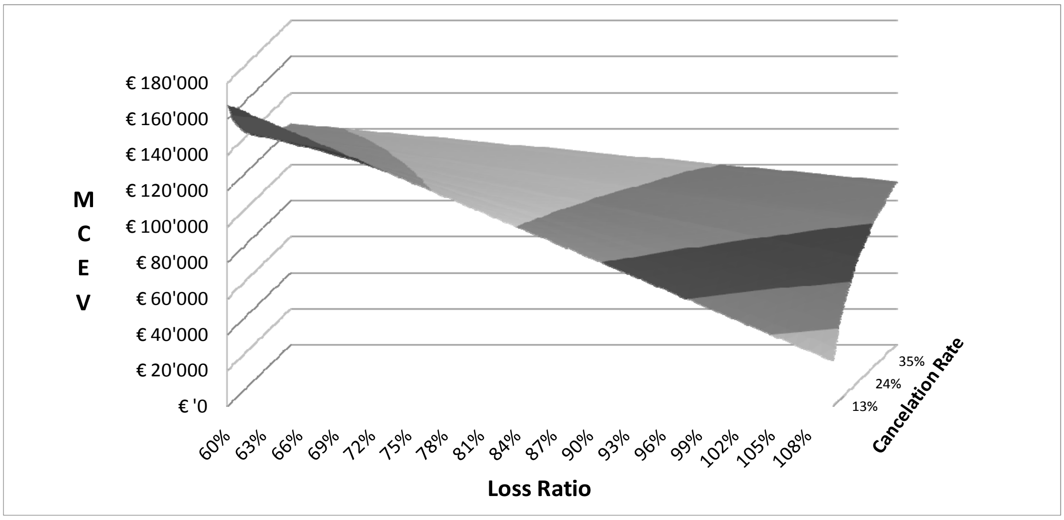

Figure 7: Loss Ratio Versus Cancellation Rate

Second, we consider variations in loss ratios and acquisition costs (see Figure 8) for a given cancellation rate of 13%. In this situation, there is a linear relationship between these two ratios: the higher the costs and the higher the loss ratio, the lower the MCEV (and, therefore, the lower the VIF). MCEV results range from a maximum of € 168,553 to a minimum of € 3,228.VIF results range from a maximum of € 119,352 to a minimum of minus € 45,973. For a loss ratio of about 83% and a corresponding acquisition cost rate higher than 33%, the VIF becomes negative and the insurance business is unprofitable.

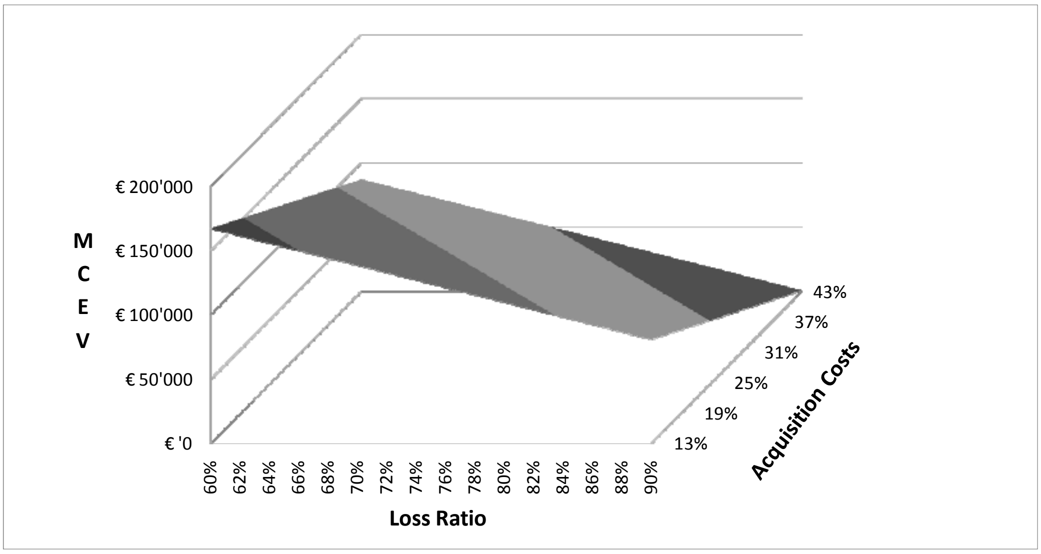

Figure 8: Loss Ratio Versus Acquisition Costs

Value Added Analysis

To this point, we have only considered the MCEV in t=0. We now analyze MCEV over time, i.e., changes from t=0 to t=1 (we denote this as value added), based on the detailed movement analysis template provided by the European Insurance CFO Forum (2009a; MCEV Principle 17). The goal is to analyze the so-called MCEV earnings which are defined as the sum of the change in MCEV over a period plus the value of distributions to the shareholders from the assets backing the covered business (see European Insurance CFO Forum, 2009a). In this paper, we limit our analysis to a basic breakdown of the value added consisting of changes within free surplus, required capital, present value of future profits, frictional costs of required capital, and costs of residual and nonhedgeable risks. We consider Scenario 2 with a cancellation rate of 13%.

In Example 1, we assume that the actual development of the insurance company over the first year coincides with the development assumed in the MCEV calculation at t=0 (e.g., regarding number of renewals, investment income, claim payments, and reserves). Furthermore, we assume that the economic assumptions underlying the MCEV calculation at t=1 are the same as those at t=0. We do not take into account the value of any new business written, but only consider a process that settles the existing business (including renewals) at the beginning of the year to arrive at an expected status at the end of the year. As a simplified management rule, we assume the free surplus to be distributed to the shareholders right the start of year 1. The MCEV results with a basic breakdown are shown in Table 4.

	PVFP	FCRC	CRNHR	RC	FS	MCEV
Opening MCEV	98,325	-2,132	-7,489	30,288	18,913	137,905
Opening Adjustment					-18,913	-18,913
Unwinding	3,850	-83	-293			3,474
Release of RC				-8,611	8,611	
Release of FCRC		421				421
Release of CRNHR			1,817			1,817
Closing Adjustment	-37,312					-37,312
Closing MCEV	64,863	-1,794	-5,965	21,677	8,611	87,392

Table 4: MCEV Results for Example 1 (Unwinding of Business, Unchanged Assumptions)

As reported in the previous section, the MCEV in t=0 is € 137,905 (Opening MCEV). We now assume that one year has passed and we observe a total MCEV of € 87,392 (Closing MCEV), a decrease of € 50,513, a seemingly unsatisfactory state of affairs. However, at the beginning of year 1, free surplus in the amount of € 18,913 is paid out to the shareholders (Opening Adjustment). Additionally, at t=1 the annual net income in the amount of € 37,312 is not reinvested in the insurance company, but paid as dividends to the shareholders (Closing Adjustment). Thus, the net effect of actual payments to shareholders (dividends) and decrease in MCEV (value added) leads to overall MCEV earnings in the amount of € 5,712 (=18,913 + 37,312 – 50,513).

We use the basic breakdown of the MCEV elements shown in Table 4 to illustrate where the positive net effect comes from. First, due to the fact that we are now making calculations in t=1, we must discount the present value of future profits, frictional costs of required capital, and costs of residual and nonhedgeable risks by one year less than in t=0. This leads to a total discount effect in the amount of € 3,474, consisting of a positive effect within PVFP amounting to € 3,850 and a negative effect within FCRC amounting to € 83 and within CRNHR amounting to € 293. The total discount effect corresponds to the unwinding of our insurance business. Second, while the required capital decreases by € 8,611, we have an increase of free surplus in the same amount. Some portion of the required capital is thus released and transferred to the free surplus, which will be paid out to shareholders right at the start of year 2. Hence, the release of RC does not have any impact on our total MCEV earnings. In addition to the discount effect and the release of RC, we also have to take into account the release of FCRC allowance in the amount of € 421 and of CRNHR allowance in the amount of € 1,817.[13] Our total MCEV earnings in the amount of € 5,712 can thus be explained by a discount effect and a release of cost of capital allowance within FCRC and CRNHR.

[13] The actual costs of residual and nonhedgeable risks correspond to the cost of capital that occurred during the time period t=0 to t=1. Performance metrics such as economic value added (EVA; see Malmi and Ikäheimo, 2003) make explicit allowance for a cost of capital rate. A more detailed comparison of MCEV earnings and EVA is necessary to analyze similarities and differences between these concepts.

Example 1 pointed out the model implications of unchanged assumptions at different points in time; we now analyze changes to the economic assumptions set out in t=0 (Example 2). The aim of this second example is to identify the value added by the management of an insurer. The value added observed from t=0 to t=1, however, will always show a combination of external and internal effects. External effects are due to changes in the market environment, i.e., the capital market or the insurance market, among others. Only abnormal deviations from these overall market developments can be attributed to management, i.e., internal effects. Again, we consider only an unwinding process and do not take into account the value of any new business written.

The following calculations are based on the assumptions shown in Table 5, where we describe both the development of the firm as well as that of the market in year 0 and year 1. What is needed to divide external from internal effects is a benchmarking with the market development from t=0 to t=1. We thus turn to the market data in order to separate the effects due to changes in the business environment from those due to skillful management. For example, we assume the average cancellation rate in the market to be 10.00% in t=0, a value that is substantially lower than the 13.00% observed for the company. In t=1, the market average is 9.50%, which is 5.00% lower than the 10.00% observed as a market average in the previous year. The reduction in the insurer's cancellation rate, however, is only 3.84% (12.50%/13.00%). It thus appears that in this year the company performed worse than the market because it could not reduce the cancellation rate to the same extent as did the market.

Data	**Company**		**Market**		**Delta Market**	**Company (External)**
	t=0	t=1	t=0	t=1		t=1
Cancellation Rate	13.00%	12.50%	10.00%	9.50%	-5.00%	12.35%
Loss Ratio	70.80%	70.60%	71.00%	70.00%	-1.40%	69.81%
Acquisition Costs	13.00%	12.50%	12.00%	11.00%	-8.33%	11.92%
Claim Settlement Costs	4.00%	3.90%	5.00%	4.60%	-8.00%	3.68%

Table 5: Modified Operating Assumptions used for Example 2

The total results of our MCEV calculations are shown in Table 6. We assume that the changes to our operating assumptions took place within calendar year t=0 to t=1. Thus, not only the valuation in t=1, but also the development over the year, are based on the new economic assumptions shown in Table 5.

	PVFP	FCRC	CRNHR	RC	FS	MCEV
Opening MCEV	98,325	-2,132	-7,489	30,288	18,913	137,905
Opening Adjustment					-18,913	-18,913
Unwinding	3,850	-83	-293			3,474
Experience Variances	657					657
Assumption Changes	2,989	-51	-213	98	-98	2,725
Release of RC				-8,484	8,484	
Release of FCRC		422				422
Release of CRNHR			1,823			1,823
Closing Adjustment	-37,969					-37,969
Closing MCEV	67,852	-1,844	-6,172	21,902	8,386	90,124

Table 6: MCEV Results for Example 2 (Unwinding of Business, Modified Assumptions)

The MCEV of the company in t=0 is again € 137,905. Calculating MCEV at t=1 with the new company input parameters as shown in Table 5 leads to an total MCEV of € 90,124, a decrease of € 47,781. As mentioned, opening and closing adjustments correspond to actual payments to shareholders at the beginning and at the end of the year.[14] After the opening adjustment (the same amount as in Example 1), we consider the unwinding of our insurance business due to the fact that we now have to discount by one year less than in year 0. Hereby we use the same operating assumptions as in t=0.[15] Besides the unwinding, the release of RC, FCRC, and CRNHR, we now also have to take into account the fact that experiences in the first year differed from expectations (*Experience Variances*) and the impact of changes in our operating assumptions (*Assumption Changes*).[16] The overall MCEV earnings in year 1 are thus € 9,101 (= 18,913 + 37,969 – 47,781).

However, it is not yet clear whether this result is due to internal effects or due to changes in the market environment. To separate out internal and external effects, we now calculate a hypothetical MCEV of the company based on market data. For this purpose we multiply the company values in t=1 by the changes in market data (e.g., the cancellation ratio of the com-

[14] The free surplus and the annual net income are paid out to shareholders as dividends.

[15] This part thus corresponds to the € 3,474 shown in Example 1. The additional discount effect based on the modified operating assumptions (Table 5) is part of the assumption changes (in Table 6). Alternatively, one could also show the unwinding of the insurance business based on the new operating assumptions.

[16] Experience variances and assumption changes could be split further between operative and economic variances/assumptions. In order to more closely distinguish the impact of experience variances from assumption changes further considerations are necessary.

pany (external) in t=1 is given by 13.00% * (9.50%/10.00%) = 12.35%) and then again calculate MCEV. This allows us to further split both experience variances and assumption changes into market impact and deviations from the market, as shown in Table 7.

	PVFP	FCRC	CRNHR	RC	FS	MCEV
Experience Variances	657					657
… market impact	*2,173*					*2,173*
… deviation from market	*-1,516*					*-1,516*
Assumption Changes	2,989	-51	-213	98	-98	2,725
… market impact	*6,686*	*-62*	*-256*	*127*	*-127*	*6,368*
… deviation from market	*-3,697*	*11*	*43*	*-29*	*29*	*-3,643*

Table 7: Market Impact for Example 2 (Unwinding of Business, Modified Assumptions)

If the company had performed as well as the benchmark (the market), it should have provided MCEV earnings in the amount of € 14,260 (=2,173 + 6,368 + 3,474 + 422 + 1,823) from t=0 to t=1. In fact, however, it only provided MCEV earnings of € 9,101. We thus conclude that the MCEV earnings attributable to the management are € –5,159 (= –1,516 – 3,643).

Management might claim that it is not responsible for this value destruction, e.g., it might claim that its customers are not well represented by the market average. This illustrates that it is important to identify the right benchmark for the value added analysis.[17] However, if it is indeed true that, in general, the insurer's customers are not similar to the market average, such a situation could also be interpreted as showing that this company has not done well at diversifying its risk. Risk diversification, however, is a crucial management task, and so, despite management's objections, once again it could be fairly concluded that the value destruction was its fault.

Overall, our concept of value added analysis is very similar to the concept of economic value added (*EVA*) (see Stern, Stewart and Chew, 1995), both of which can be traced back to the Marshall's (1890) residual income concept. In the case of economic value added (or residual income), the annual result is related to the cost of capital (hurdle rate times equity capital).

[17] A requirement for the benchmark is that it should be comparable to the insurer's business in terms of risk and return. For criteria appropriate in selecting representative benchmarks, see Sharpe (1992).

One difference between residual income and the concept presented here is that our benchmark is not a hurdle rate, but the market average. However, it may be feasible to transfer the idea of hurdle rate into a concept of MCEV target value (MCEV * (1 + hurdle rate)). We then could compare the realized MCEV in t=1 with the MCEV target value. The concept can thus be used ex post for performance measurement, and also ex ante for value-based management and target setting. However, it is important to emphasize that MCEV ignores future new business and this might distort decision making. The management implications of MCEV must thus be considered very carefully.

Another idea is to break down the value added by management into that attributable to different parts of the company, i.e., how much value added has been generated by the asset management, by claims management, or by other segments of the insurer's business? However, this task is hardly feasible because it leads to problems well known from capital allocation, i.e., it is not feasible to allocate capital to different business units without arbitrary assumptions, especially when there is no allocation mechanism for overhead costs (see Gründl and Schmeiser, 2007).

6. Conclusions

The aim of this paper was to illustrate the determination of market-consistent embedded value in non-life insurance. Traditionally, embedded value determination is used for long-term business, such as life insurance. In this paper, we transferred the embedded value concept from life to non-life insurance. In our numerical illustration of the model, we showed an MCEV calculation based on empirical data and set up an economic balance sheet. Furthermore, we illustrated how the different value components can be allocated to different stakeholders and we analyzed the value implications of varying loss ratios and costs with a sensitivity analysis. Finally, the potential usefulness of the model for value-based management was illustrated by a value added analysis.

The proposed model framework has a number of important practical implications. First, it provides new and relevant information to the stakeholders of an insurance company. The model provides information comparable to that provided by embedded value models currently used in the life insurance industry and fills a gap in the literature. The concept of MCEV also has potential for value-based management of an insurance company, although its management implications must be considered very carefully. Managing insurance companies without making reasonable assumptions as to future new business might distort decision making and thus lead to dangerous misallocation, especially if management compensation is linked to MCEV. Nevertheless, embedded value models are already used for compensation in the life insurance industry and future research is needed to analyze the relationship between the MCEV (reflecting current business) and a market-consistent appraisal value (reflecting both current business as well as future new business).

Future research could extend this model in several directions. The presented model can be extended to include inflation, reinsurance, more realistic claim processes, or a more realistic description of the cost situation in an insurance company. Moreover, by taking a closer look at the premium renewal process in non-life insurance, the deterministic process employed in this paper could be replaced by a stochastic model. Furthermore, now that two concepts based on the same principles have been developed it would be interesting to combine the concepts for life and non-life and come up with a *group MCEV*. Furthermore, another question arising out of solvency regulation (Solvency II) is whether the concept of MCEV can be used to derive capital requirements, e.g., at the insurance-group level.

Appendix A: Modeling of MCEV

Appendix A1

As mentioned, for cash flows that vary linearly with market movements a certainty-equivalent approach can be used. This is the case for non-life insurance contracts as there are no financial options and guarantees. For this purpose, we need the risk-free yield curve at t=0, consisting of spot rates (sr_t) for each relevant time to maturity. The corresponding discount rates (dr_t) are derived from the spot rate by $dr_t = \frac{1}{(1+sr_t)^t}$. Under the certainty-equivalent approach, the investment return for year t is given by the implied forward rate $fr_t = \left(\frac{(1+sr_t)^t}{\prod_{i=1}^{t-1}(1+fr_i)}\right) - 1$. For $t = 1$, the forward rate fr_1 coincides with the spot rate sr_1.

Appendix A2

The in-force covered business in non-life insurance should contain a reasonable proportion of renewal business when modeling the MCEV. Therefore, we conducted two separate analyses, one for unwinding the existing business and the second containing provisions for renewal business. In a third step, these are aggregated to the overall result.

<u>Step 1: Modeling of Existing Business</u>

For the settlement process of our existing business, we start with the (undiscounted) best estimate claim reserves at the beginning of our calculations ($\mathrm{BCR}_0^{\mathrm{eb}}$). This can be derived by deterministic or stochastic reserving methods (see, e.g., England and Verrall, 2002). In addition to the best estimate reserves, we also need a payment pattern ($\mathrm{pr}_t^{\mathrm{eb}}$) as an assumption for how the best estimate claim reserves will be paid out within the next few years. The claim payments from existing business can be derived by:

$$\mathrm{CP}_t^{\mathrm{eb}} = \mathrm{BCR}_0^{\mathrm{eb}} * \mathrm{pr}_t^{\mathrm{eb}}. \tag{A1}$$

The development of the (undiscounted) best estimate claim reserves $\mathrm{BCR}_t^{\mathrm{eb}}$ for existing business would then only be the effect of a settlement process, which is given by the future claims paid $\mathrm{CP}_t^{\mathrm{eb}}$ ($\mathrm{BCR}_t^{\mathrm{eb}} = \mathrm{BCR}_{t-1}^{\mathrm{eb}} - \mathrm{CP}_t^{\mathrm{eb}}$), with $\mathrm{BCR}_T^{\mathrm{eb}} = 0$. In order to determine the discounted best estimate claim reserves for the existing business (BCR_t^{ebDIS}) we sum up the product of discounted future claim payments and then project them into the future:

$$BCR_t^{ebDIS} = \begin{cases} \sum_{i=1}^{T}\left(CP_i^{eb} * dr_i\right) \ , t = 0 \\ \left(BCR_{t-1}^{ebDIS}\right) * (1 + fr_t) - CP_t^{eb} \ , t > 0. \end{cases} \tag{A2}$$

For the claim reserves $\mathrm{CR}_\mathrm{t}^\mathrm{eb}$ according to local GAAP, in a simplified management rule, we assume that management will always ensure that the settlement process proceeds equally (proportionally constant) to the settlement process of best estimate claim reserves BCR_t^{eb}, given by a constant percentage $c = \frac{\mathrm{CR}_0^\mathrm{eb}}{\mathrm{BCR}_0^\mathrm{eb}}$, i.e., $\mathrm{CR}_\mathrm{t}^\mathrm{eb} = \mathrm{BCR}_\mathrm{t}^\mathrm{eb} * c$.

Step 2: Modeling of Renewal Business

For the existing business, we considered only a settlement process, which means that we did not take into account any future renewals of our insurance contracts. We now make allowance for renewal business and consider future gross premiums earned. Thus, we first have to model the underlying portfolio development. Our starting point at t=0 is the existing insurance portfolio containing a given number of insurance contracts (IC). Furthermore, we assume an average cancellation rate (cr) , and an average premium level (PL), as well as a best estimate loss ratio (lr) for the total insurance portfolio. We assume that all these values are based on historical experience data. In our model, we divide the portfolio into three revenue segments: A, B, and C (with proportions given by ac^m). The segments differ with respect to cancellation rate (ci^m) and premium level (pi^m). This allows us to derive all relevant parameters for each revenue segment at our starting point t=0 ($IC_0^m = IC * ac^m$, $cr_0^m = cr * ci^m$, $P_0^m = PL * pi^m$ and $lr_0^m = lr * pi^m$).

In a second step, we determine the remaining number of insurance contracts in each revenue segment for the respective accident year i, $IC_i^m = IC_0^m * \max(1 - i * cr_0^m; 0)$. With this information, we are able to calculate the gross premiums earned for accident year i for the appropriate revenue segment A, B, or C, i.e., $GPE_i^m = IC_i^m * P_0^m$. The total gross premiums earned for accident year i (GPE_i) from all revenue segments (A, B, and C) can be calculated by the sum of gross premiums earned within the respective revenue segment ($GPE_i = \sum_{m=A}^{C}(GPE_i^m)$).

In a third step, the total ultimate loss of accident year i can be derived by the sum of the ultimate loss within the respective revenue segment, $UL_i = \sum_{m=A}^{C}(UL_i^m)$. Thereby, UL_i^m is the product of gross premiums earned and the respective loss ratio:

$$UL_i^m = GPE_i^m * lr_0^m. \tag{A3}$$

Claim payments for renewal business can be represented in a payment process triangle, as shown in Figure A1. Here, we have absolute accident years i ($i = 1, \dots, K$) on one side and absolute calendar years j ($j = 1, \dots, T$) on the other side (with K < T). This naturally leads to future claim payments of zero in the case that the actual calendar year is before the accident year ($CP_{i,j} = 0, j < i$). In any other case, the future claims paid can be calculated by considering the ultimate loss amount of accident year i (UL_i) and a predefined payment pattern for renewal business (pr_t^{rb}), ($CP_{i,j} = UL_i * pr_{j+1-i}^{rb}, i \leq j$).

		Calendar Year j						
		1	2	⋯	j	⋯	T-1	T
Accident Year i	1	$CP_{1,1}$	$CP_{1,2}$			⋯	$CP_{1,T-1}$	$CP_{1,T}$
	2	0	$CP_{2,2}$					
	⋮	0	0					
	i	0	0	0	$CP_{i,j}$			
	⋮	0	0	0	0			
	K-1	0	0	0	0	0		
	K	0	0	0	0	0	0	$CP_{K,T}$

Figure A1: Payment Process Triangle

The total claim payments for renewal business at calendar year t, CP_t^{rb} , can now be calculated by summing up all the columns of our payment process triangle:

$$CP_t^{rb} = \sum_{i=1}^{t} CP_{i,t}. \quad \text{(A4)}$$

The development of the best estimate claim reserves for the respective accident year i and calendar year t ($BCR_{i,t}$) can then be derived by summing up the future claims paid $CP_{i,t}$ (as shown in Figure A1): $BCR_{i,t} = \sum_{k=t+1}^{T} CP_{i,k}$. The total *best estimate claim reserves* of renewal business at the end of calendar year t, BCR_t^{rb}, can now be calculated by summing over all past accident years:

$$BCR_t^{rb} = \sum_{i=1}^{t} BCR_{i,t} = \sum_{i=1}^{t} \sum_{k=t+1}^{T} CP_{i,k}. \quad \text{(A5)}$$

We now determine the *discounted best estimate claim reserves* for renewal business at time t (BCR_t^{rbDIS}). This requires appropriate discount rates, $dr_{t,k}$, for each point in time t, which are applied to the relevant future cash flows occurring at k= t+1, …, T. Under the certainty-equivalent approach, these discount rates can be derived from the forward rates at t=0, i.e., $dr_{t,k} = \frac{1}{\prod_{j=1}^{k-t}(1+fr_{t+j})}, (k > t)$. The relevant cash flows relate only to accident years before the valuation date t. Therefore, the discounted best estimate claim reserves can be derived by:

$$BCR_t^{rbDIS} = \sum_{k=t+1}^{T}\left\{\sum_{i=1}^{t} CP_{i,k}\right\} * dr_{t,k}. \tag{A6}$$

To calculate *claim reserves for renewal business according to the local GAAP* ($\mathrm{CR}_\mathrm{t}^\mathrm{rb}$), again, in a simplified management rule we assume that the settlement process will proceed equally (proportionally constant) to the settlement process of the best estimate claim reserves, given by the same constant c as shown above ($c = \frac{\mathrm{CR}_0^{\mathrm{eb}}}{\mathrm{BCR}_0^{\mathrm{eb}}}$), i.e., $\mathrm{CR}_\mathrm{t}^\mathrm{rb} = \mathrm{BCR}_\mathrm{t}^\mathrm{rb} * c$.

Step 3: Calculation of Overall Result

To obtain the overall result of the MCEV calculations, we add existing business and renewal business. We assume independency between the claim settlement process of existing business and renewal business. Thus, the sum of claim payments for existing business CP_t^{eb} and claim payments for renewal business CP_t^{rb} lead to total claim payments in the amount of CP_t, ($CP_t = CP_t^{eb} + CP_t^{rb}$). In addition, best estimate claim reserves undiscounted as well as discounted can be shown as the sum of existing and renewal business ($BCR_t = BCR_t^{eb} + BCR_t^{rb}$; $BCR_t^{Dis} = BCR_t^{ebDIS} + BCR_t^{rbDIS}$). For claim reserves according to local GAAP, we also employ a sum ($\mathrm{CR_t} = \mathrm{CR_t^{eb}} + \mathrm{CR_t^{rb}}$).

For the settlement process of the equalization reserves, we assume that the equalization reserves at the beginning of our calculations ER_0, which come from the statutory balance sheet, would be equally settled to the best estimate claim reserves. Thus, we need the proportion of these two measures from the beginning of our calculations ($c = \frac{\mathrm{ER_0}}{\mathrm{BCR_0}}$), i.e., $ER_t = BCR_t * c$.

Acquisition costs can be calculated as the product of gross premiums earned and a predefined acquisition cost rate, acr_t , at valuation date t ($AC_t = GPE_t * acr_t$). Claim settlement costs can be calculated as the product of claim payments and a predefined claim settlement costs rate, $cscr_t$, at valuation date t ($CSC_t = CP_t * cscr_t$). Overhead costs would be derived by the maximum of a predefined minimum for overhead costs, OC^{Min} , and the overhead costs development driven by development of the best estimate claim reserves given through $c = \frac{OC_0}{BCR_0}$ ($OC_t = Max(OC^{Min}; BCR_t * c)$.

Appendix A3

We assume that at time t=0, the amount of ugl is equal to a prespecified percentage of the book value of assets, i.e., $MV_0^{abl} = BV_0^{abl} * (1 + ugl)$. Derivation of the technical result includes a projection of both the claim reserves and the equalization reserves under local GAAP, where the sum of these is called the book value of liabilities, i.e., $BV_t = CR_t + ER_t$. The book value of assets backing liabilities under local GAAP (BV_t^{abl}) must be greater than or equal to the book value of liabilities (BV_t) to satisfy the funding requirements (otherwise the shareholders would need to make additional contributions). The cash flow at time t corresponds to:

$$CF_t = GPE_t - CP_t - AC_t - CSC_t - OC_t - T_t = \Delta CR_t + \Delta ER_t. \quad \text{(A7)}$$

Note that T_t is paid to the shareholders at time t and is therefore included in the cash flow above. Overall, this shows that $BV_t = BV_{t-1} + \Delta CR_t + \Delta ER_t = BV_{t-1} + CF_t$.

Under the certainty-equivalent approach, the investment income on a market value basis is given by the forward rates rate fr_t for each year t. We assume that investment costs are proportional to the market value of assets (icr) and that all cash flows occur at the end of the year. The resulting investment income is called the investment result on market value basis and is given by $I_t^{MV} = MV_{t-1}^{abl} * (fr_t - icr)$. Under German local GAAP, there is some management discretion regarding the realization of gains or losses on assets. Therefore, the investment income on local GAAP basis may differ significantly from the investment income on market value basis shown above.

In a simplified management rule, we assume that management will always ensure that the book value of assets backing liabilities is equal to the book value of liabilities, i.e., $BV_t^{abl} = BV_t$. Furthermore, we assume that *ugl* will be built up/dissolved such that the ratio of *ugl* remains unchanged, i.e., $MV_t^{abl} = BV_t^{abl} * (1 + ugl)$. This can be achieved by realizing gains/losses equal to $ugl * (BV_{t-1} - BV_t)$ so that the overall investment income on book value basis is equal to:

$$I_t = MV_{t-1}^{abl} * (fr_t - icr_t) + ugl * (BV_{t-1} - BV_t). \quad \text{(A8)}$$

A positive investment income would be paid to the shareholders, whereas a negative investment income would require further funds.

Appendix A4

According to German law on the supervision of insurance undertakings and local regulation rules, $SCR\ I_t$ can be calculated by the maximum of a minimum amount provided by legal regulations MIN, a premium index PI_t, a claim index CI_t , and, in the case of $t > 0$, the adjustment of $SCR\ I_{t-1}$ via the development factor of claim reserves ($SCR\ I_0$ at valuation date $t = 0$ equals to $SCR\ I$):

$$SCR\ I_t = \begin{cases} Max(MIN; PI_t; CI_t)\ , t = 0 \\ Max\left(MIN; PI_t; CI_t; \frac{CR_t}{CR_{t-1}} * SCR\ I_{t-1}\right), t > 0 \end{cases}. \tag{A9}$$

The premium index and the claim index are calculated as described in Solvency I (see § 53c of the German Insurance Supervision Act). GPE_t denotes gross premiums earned at valuation date t, CP_t denotes claim payments, and ΔCR_t ($\Delta CR_t = CR_t - CR_{t-1}$) denotes changes in claim reserves. The premium index is calculated as $PI_t = 18\% * Min(53{,}100; GPE_t) + 16\% * Max(GPE_t - 53{,}100; 0)$; the claim index is given by $CI_t = 26\% * Min(37{,}200; CP_t + \Delta CR_t) + 23\% * Max((CP_t + \Delta CR_t) - 37{,}200; 0)$.

According to the current status of the EU regulations, $SCR\ II_t$ can be calculated as sum of the so-called basic solvency capital requirements ($BSCR_t$) and the solvency capital requirements for operational risks (SCR_t^{or}) (see CEIOPS, 2008). The basic solvency capital requirements can be divided into SCR for premium risk (SCR_t^{pr}) and SCR for reserve risk (SCR_t^{rr}). The Solvency II calculations also include the correlation factor x. $SCR\ II_t$ at valuation date $t = 0$ equals the $SCR\ II$ needed in formula (2):

$$SCR\ II_t = (BSCR_t + SCR_t^{or}), \tag{A10}$$

with $BSCR_t = \sqrt{\begin{pmatrix} SCR_t^{rr} & SCR_t^{pr} \end{pmatrix} * \begin{pmatrix} 1 & x \\ x & 1 \end{pmatrix} * \begin{pmatrix} SCR_t^{rr} \\ SCR_t^{pr} \end{pmatrix}}$. To calculate SCR_t^{or}, we need the discounted best estimate claim reserves at valuation date *t* (BCR_t^{Dis}), a predefined operational risk rate for the reserve risk (orr^{rr}) and a predefined operational risk for premium risk (orr^{pr}). SCR_t^{or} is then calculated as: $SCR_t^{or} = Max(BCR_t^{Dis} * orr^{rr}; GPE_{t+1} * orr^{pr})$. $SCR_t^{rr} = CR_t^{dbe} * \frac{SCR_0^{rr}}{CR_0^{dbe}}$ and $SCR_t^{pr} = GPE_{t+1} * \frac{SCR_0^{pr}}{GPE_1}$, whereas SCR_0^{rr} and SCR_0^{pr} can be derived, e.g., using internal risk models based on dynamic financial analysis (see Eling/Toplek, 2009).

Appendix B: Parameters for Application of MCEV

Parameter	Value	Parameter	Value	Parameter	Value	Parameter	Value
$\mathrm{BV}_0^{\mathrm{abse}}$	€ 48,236	tr	32.00 %	cscr	4.00 %	MIN	€ 2,200
$\mathrm{BV}_0^{\mathrm{abl}}$	€ 187,883	IC	535,471	OC^{min}	€ 500	x	20.00 %
SE_0	€ 48,236	PL	€ 250	OC_0	€ 3,800	orr^{rr}	2.00 %
ER_0	€ 33,932	cr	13.00 %	BCR_0^{eb}	€ 95,374	orr^{pr}	2.00 %
CR_0	€ 153,951	lr	70.80 %	icr	0.20 %	SCR_0^{rr}	€ 17,900
ugl	2.00 %	acr	13.00 %	cocr	6.00 %	SCR_0^{pr}	€ 21,000

Table B1: Parameters

Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
pr_t^{eb}	69.00	9.60	6.50	3.20	2.50	1.60	1.40	1.00	0.60	4.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
pr_t^{rb}	69.00	9.60	6.50	3.20	2.50	1.60	1.40	1.00	0.60	4.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sr_t	3.92	4.70	4.53	4.51	4.53	4.55	4.58	4.61	4.65	4.70	4.74	4.78	4.82	4.85	4.88	4.88	4.88	4.88	4.88	4.88

TableB2: Payment and Interest Rate Patterns (In Percent)

Parameter	Revenue Segment A	Revenue Segment B	Revenue Segment C
ac^m	20.00 %	60.00 %	20.00 %
ci^m	1.20	1.00	0.80
pi^m	1.30	1.00	0.70

Table B3: Revenue Segments

References

Anderson, J. C. H., 1959, Gross Premium Calculations and Profit Measurement for Nonparticipating Insurance, *Transactions of the Society of Actuaries*, 11, 357–394.

Brockett, P. L., Cooper, W. W., Golden, L. L., and Pitaktong, U., 1994, A Neural Network Method for Obtaining an Early Warning of Insurer Insolvency, *Journal of Risk and Insurance*, 61(3), 402–424.

Cairns, A. J. G., Blake, D., and Dowd, K., 2006, A Two-Factor Model for Stochastic Mortality with Parameter Uncertainty: Theory and Calibration, *Journal of Risk and Insurance*, 73(4), 687–718.

CEIOPS, 2008, Committee of European Insurance and Occupational Pensions Supervision: CEIOPS' Report on its Fourth Quantitative Impact Study (Quis 4) for Solvency II.

Chen, R., and Wong, K. A., 2004, The Determinants of Financial Health of Asian Insurance Companies, *Journal of Risk and Insurance*, 71(3), 469–499.

Cummins, A. R., Rubio-Misas, M., and Zi, H., 2004, The Effect of Organizational Structure on Efficiency: Evidence from the Spanish Insurance Industry, *Journal of Banking & Finance*, 28, 3113–3150.

DAV-Arbeitsgruppe Interne Modelle, 2008, Interne Risikomodelle in der Schaden-/Unfallversicherung. Deutsche Gesellschaft für Versicherungs- und Finanzmathematik, Verlag Versicherungswirtschaft, Karlsruhe.

De Mey, J., 2009, Reporting on the Financial Performance of Life Insurers, *Geneva Papers on Risk and Insurance* 34, 228–241.

Eling, M., and Toplek, D., 2009, Modeling and Management of Nonlinear Dependencies–Copulas in Dynamic Financial Analysis, *Journal of Risk and Insurance*, 76 (3), 651–681.

Eling, M., Gatzert, N., and Schmeiser, H., 2009, Minimum Standards for Investment Performance: A New Perspective on Non-Life Insurer Solvency, *Insurance: Mathematics and Economics*, 45(1), 113–122.

England, P.D. and Verrall, R.J., 2002, Stochastic claims reserving in general insurance, *British Actuarial Journal*, 8(3), 443–518.

European Insurance CFO Forum, 2004, European Embedded Value Principles, May 2004.

European Insurance CFO Forum, 2009a, Market Consistent Embedded Value: Principles, October 2009.

European Insurance CFO Forum, 2009b, Market Consistent Embedded Value: Basis for Conclusions, October 2009.

Exley, C. J., and Smith, A. D., 2006, The Cost of Capital for Financial Firms, *British Actuarial Journal*, 12(1), 229–301.

Gatzert, N., and Kling, A., 2007, Analysis of Participating Life Insurance Contracts: A Unification Approach, *Journal of Risk and Insurance*, 74(3), 547–570.

Gatzert, N., and Schmeiser, H., 2008, Assessing the Risk Potential of Premium Payment Options in Participating Life Insurance Contracts, *Journal of Risk and Insurance*, 75(3), 691–712.

Gründl, H., and Schmeiser, H., 2007, Capital Allocation for Insurance Companies—What Good is It? *Journal of Risk and Insurance*, 74(2), 301–317.

Jeng, V., and Lai, G. C., 2005, Ownership Structure, Agency Costs, Specialization, and Efficiency: Analysis of Keiretsu and Independent Insurers in the Japanese Nonlife Insurance Industry, *Journal of Risk and Insurance*, 72 (1), 105–158.

Klein, R. W., and Wang, S., 2009, Catastrophe Risk Financing in the United States and the European Union: A Comparative Analysis of Alternative Regulatory Approaches, *Journal of Risk and Insurance*, 76 (3), 607–637.

Liebenberg, A. P., and Hoyt, R. E., 2003, The Determinants of Enterprise Risk Management: Evidence from the Appointment of Chief Risk Officers, *Risk Management and Insurance Review*, 6(1), 37–52.

Malmi, T., and Ikäheimo, S., 2003, Value Based Management Practices—Some Evidence from the Field, *Management Accounting Research*, 14(3), 235–254.

Marshall, A., 1890. *Principles of Economics*. London: Macmillan Press Ltd.

Maurer, R., and Somova, B., 2007, German Insurance Industry: Market Overview and Trends, in: Cummins, J. D., and Venard, B. (Eds.): *Handbook of International Insurance*, Berlin: Springer, 305–345.

Nakada, P., Shah, H., Koyluoglu, H. U., and Colignon, O., 1999, RAROC: A Catalyst for Improved Capital Management in the Property and Casualty Insurance Industry, *Journal of Risk Finance*, 1(1), 1–18.

O'Keeffe, P. J. L., Desai, A. J., Foroughi, K, Hibbett, G. J., Maxwell, A. F., Sharp, A. C., Taverner, N. H., Ward, M. B., and Willis, F. J. P., 2005, Current Developments in Embedded Value Reporting, *British Actuarial Journal*, 11(3), 407–479.

Olivieri, A., and Pitacco, E., 2008, Assessing the Cost of Capital for Longevity Risk, *Insurance: Mathematics and Economics*, 42(3), 1013–1021.

Plat, R., and Pelsser, A., 2009, Analytical Approximations for Prices of Swap Rate Dependent Embedded Options in Insurance Products, *Insurance: Mathematics and Economics*, 44(1), 124–134.

Post, T., Gründl, H., Schmidl, L., and Dorfman, M. S., 2007, Implications of IFRS for the European Insurance Industry—Insights from Capital Market Theory, *Risk Management and Insurance Review*, 10(2), 247–265.

Risk Management Metrics Subgroup, 2001, Embedded Value Definition, Working Paper, Society of Actuaries.

Sharpe, W. F., 1992, Asset Allocation: Management Style and Performance Measurement, *Journal of Portfolio Management*, 18, 7–19.

Sheldon, T. J., and Smith. A. D., 2004, Market Consistent Valuation of Life Assurance Business, *British Actuarial Journal*, 10(3), 543–626.

Stern, J. M., Stewart, G. B., III, and Chew, D. H., Jr., 1995. The EVA® Financial Management System. *Journal of Applied Corporate Finance*, 8(2), 32–46.

Towers Perrin, 2008, Life Insurance CFO Survey #20: Measuring Embedded Value, August 2008.

Vasicek, O., 1977, An Equilibrium Characterisation of the Term Structure, *Journal of Financial Economics*, 5, 177–188.