Underwriting Cycles in German Property-Liability Insurance

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Abstract: Underwriting cycles, i.e., cyclical patterns in property-liability insurance prices and profits, are a phenomenon that has found broad acceptance among academics and practitioners in the insurance industry within the last years. In particular, they have been incorporated into enterprise risk management, solvency models, and market scenario analysis. This paper contributes to the empirical literature by considering underwriting cycles in German property-liability insurance from 1957 to 2006 for the full market and for nine lines of business. Mean cycle lengths in the German market range between 3.3 years (homeowners) and 7.5 years (credit), with an average of 5.3 years for the whole market. A novel sensitivity analysis on cycle lengths provides a test of the capacity constraint hypothesis, which is rejected based on our empirical data.

JEL Classification: C22, E32, G22

Keywords: Underwriting Cycles, Property-Liability Insurance, German non-life insurance, Premium Change Anaysis

1 Introduction

Underwriting cycles, i.e., the cyclical patterns in insurance prices and profits, have been extensively researched for the United States and to some degree for Europe and Asia. Despite the ongoing academic dispute with regard to their causes, the existence of underwriting cycles has found broad acceptance in academia and practice. Underwriting cycles are incorporated into enterprise risk management and solvency models, such as, e.g., models based on dynamic financial analysis (see, e.g., Kaufmann/Gadmer/Klett, 2001). Furthermore, findings on insurance cycles are used in forecasting and scenario analysis on hard and soft market phases. This is particularly crucial for market entry and exit strategies of insurance companies (see, e.g, Chen/Wong/Lee, 1999).

Empirical work on underwriting cycles in Germany consists of only a few studies and mainly concerns the property-liability market as a whole because by-line data is not as readily available as aggregate data for the whole market (exceptions are Lamm/Tennant-Weiss, 1997, and Berry-Stölzle/Born, 2010a, 2010b). However, by-line evidence on underwriting cycles is much more meaningful since some institutional and economic variables are specific to each line of business (see Cummins/Danzon, 1997). Considering underwriting cycles as an industry-level phenomenon results in an undesirable aggregation bias (see Fields/Venezian, 1989).

Empirical evidence for Germany is especially relevant, as Germany is one of the largest insurance markets outside the US and has seen very different levels of competition in the last 50 years. After being a highly regulated, national market for many years, the market has been opened to international competition after the 1994 deregulation of European Union insurance markets. The different levels of competition might influence the cyclical pattern that we analyze throughout this paper; the German example therefore provides a good opportunity to deepen the understanding of underwriting cycles.

This paper contributes to the emerging literature on identification and analysis of industry cycles (see Tan/Mathews, 2009) by providing a comprehensive analysis of underwriting cycles for the German property-liability market. We determine the existence and lengths of underwriting cycles for the period 1957–2006 using the autoregressive process of order 2 (AR(2) process) proposed by Cummins/Outreville (1987) and frequently applied in literature. Nine lines of business are covered: motor, casualty, liability, legal, fire, transport, credit, content, and homeowners. An analysis on by-line basis has so far only been presented in Lamm/Tennant-Weiss (1997) and Berry-Stölzle/Born (2010a, 2010b). We are also interested in the sensitivity of our results depending on the time period considered. For this reason, the analysis is not limited to one investigation period (1957–2006), but considers a large number of meaningful subperiods as well. This makes our paper the first to conduct a sensitivity analysis on cycle lengths by underlying investigation period. We also study factors that cause underwriting cycles in Germany. To this end, we use an extended version of the premium change model proposed by Lamm-Tennant/Weiss (1997). A number of institutional and market factors are considered, including real Gross Domestic Product (GDP), Consumer Price Index (CPI), interest rates, stock returns, deregulation and by-line market concentration. While our focus is on a premium change analysis over a long period of time, two related papers that predate our analysis in date and focus on the effects of deregulation in the German market are Berry-Stölzle/Born (2010a, 2010b).

Our main findings can be summarized as follows. Average cycle length is 5.30 years for the whole German property-liability industry. The minimum is 3.56 years and the maximum 13.39 years, depending on the time period analyzed. For individual lines of business, cycle lengths range on average from 3.27 years (homeowners) to 7.45 years (credit). The results from our sensititvity analysis on cycle lengths contradict the capacity constraints hypothesis, which claims that underwriting cycles are most prominent in long-tail lines due to the considerable lag between premium receipt and loss payments. In the analysis of factors driving underwriting cycles, we find that the model proposed by Lamm-Tennant/Weiss (1997) has good explanatory power for the German property-liability market. We propose an extension of the Lamm-Tennant/Weiss (1997) model that increases explanatory power, e.g., by integrating the Consumer Price Index and public expenditures. Line-specific explanatory factors include registration of new vehicles (motor), changes in employment (liability), and production in construction (content, homeowners).

The rest of the paper is organized as follows. Section 2 provides an overview of the relevant literature on underwriting cycles. Section 3 introduces the methodology and the data that we use in the empirical study. Section 4 discusses the results. Section 5 concludes.

2 Underwriting Cycles: A Literature Review

2.1 What Causes Underwriting Cycles?

The existence of underwriting cycles has been proven in empirical work covering a broad range of countries and lines of business. With regard to the factors that cause underwriting cycles, however, there are numerous hypotheses, and no general consensus has been reached to date. The existing hypotheses fall into one of two main schools of thought. One of these maintains that underwriting cycles are caused by the insurers themselves because of (1) naïve rate-making methods, (2) competition-driven prices, or (3) capacity constraints. The other school of thought suggests that underwriting cycles are caused by external factors, and that insurers themselves behave rationally. The relevant hypotheses in line of this thinking attribute underwriting cycles to (4) institutional intervention, (5) the general business cycle, or (6) interest rates. The hypotheses, however, are not mutually exclusive, but can explain different aspects of the underwriting cycle. We briefly introduce these six hypotheses. For a more detailed overview, we refer to Chen/Wong/Lee (1999) and Meier/Outreville (2006).

(1) Naïve rate-making methods: Venezian (1985) suggests that underwriting cycles are caused by insurers themselves by their use of naïve forecasting procedures that rely on the extrapolation of past claims cost to calculate future rate requirements.

(2) Competition-driven prices: Many studies attribute the existence of underwriting cycles to "irrational" competitive behavior by insurance companies (see, e.g., Wilson, 1981; Stewart, 1984; Harrington/Danzon, 1994). In their struggle to gain market share, insurers deviate from their theoretical pricing models and cut their rates. Poor results then lead to subsequent cutbacks in supply and an increase in prices. The alternating phases of intense competition combined with low rates and cutback in supply combined with increased rates leads to a cycle of insurance prices and profits.

(3) Capacity constraints: The capacity constraints hypothesis claims that underwriting cycles are caused by costly external capital (see, e.g., Winter, 1988, 1991, 1994; Niehaus/Terry, 1993; Cummins/Danzon, 1997). Since insurers' capacity to provide coverage is assumed to be largely determined by the level of their internal capital, unexpected losses (e.g., in case of catastrophes) resulting in a reduction of surplus can lead to a reduction in capacity. Thus prices increase. External capital is not acquired in the short run to balance out the decrease in internal capital because doing so is costly. Reliance on limited internal capital thus leads to rigidities in insurance output and, consequently, to cyclical profits and prices. According to the capacity constraints hypothesis, the underwriting cycle should be most prominent in long-tail lines, such as liability, which are characterized by a considerable time lag between premium receipts and loss payments. The reason is that forecasting horizons are longer and anticipated investment income is more substantial for these lines (see Lamm-Tennant/Weiss, 1997).

(4) Rational expectations/institutional intervention: Cummins/Outreville (1987) suggest that underwriting cycles are not caused by irrational insurer behavior but, instead, by institutional factors. Insurers set prices under rational expectations, but prices are distorted through data collection, policy renewal, regulatory, and accounting lags, causing underwriting cycles.

(5) General business cycle: Grace/Hotchkiss (1995), and Chen/Wong/Lee (1999) analyze the relationship between underwriting cycles and the performance of national economies. They find that cycles are related to changes in the economic environment as measured by changes in real prices or real GDP.
(6) Interest rates: Insurance premiums are calculated as discounted future losses. Consequently, any change in interest rates results in a change of premiums. Therefore, changing interest rates could generate underwriting cycles (see, e.g., Wilson, 1981; Doherty/Kang, 1988; Fields/Venezian, 1989; Fung et al., 1998).

2.2 What is the Evidence for German Insurance Markets?

Table 1 provides an overview of existing empirical evidence on underwriting cycles in Germany. Cycle lengths for the German property-liability market have been calculated in studies on international underwriting cycles, such as those by Cummins/Outreville (1987, covering 13 countries), Lamm-Tenant/Weiss (1997, covering 12 countries), Meier/Outreville (2006, covering three countries), Meier (2006, covering four countries), and Swiss Re (2001, covering seven countries). Two studies present by-line cycle periods for the German property-liability business: Lamm-Tennant/Weiss (1997) and Berry-Stölzle/Born (2010b). Berry-Stölzle/Born (2010a) also analyze by-line data, but they focus on pricing and not on cycle periods which is the reason why numbers for cycle lengths are not presented in this paper.

Authors	Time Period	Branch	Cycle Lengths (Years)
Berry-Stölzle/Born (2010a)	1983-1994 vs. 1995-2004	27 lines	not presented
Berry-Stölzle/Born (2010b)	1983-1994 vs. 1995-2004	27 lines	e.g., transport 5.47 vs. 7.68
Cummins/Outreville (1987)	1957–1979	Property-liability	7.76
Lamm-Tenant/Weiss (1997)	1965–1987	Property-liability	6.45
		Auto-liability	5.47
		Fire	7.81
		Marine	12.19
		Accident	No cycle
		Liability	No cycle
		Other	4.34
Meier (2006)	1957–1997	Property-liability	10.51
	1965–1979	Property-liability	5.93
Meier/Outreville (2006)	1982–2001	Property-liability	9.93
	1975–2001	Property-liability	No cycle
	1965–2001	Property-liability	8.88
Swiss Re (2001)	1975–1999	Property-liability	6.60

Table 1: Overview of studies on underwriting cycles in Germany

The existing studies find that the average cycle length in the German property-liability market is between 5.9 and 10.5 years, depending on the time period analyzed. This is comparable to cycle lengths obtained for other countries by Lamm-Tennant/Weiss (1997): United States (6.9 years), France (6.7 years), and Switzerland (6.9 years). However, the large range of cycle lengths found in the different studies also shows the sensitivity of results with regard to the time period analyzed. For the by-line results in Lamm-Tennant/Weiss (1997), cycles in auto-liability (5.5 years) are shorter than in the property-liability market (6.5 years), while cycles are longer in fire (7.8 years) and in marine (12.2 years). For accident and liability, no cycles are found. Berry-Stölzle/Born (2010b) document structural breaks in some business lines surrounding the 1994 deregulation of the German insurance market and conclude that cycles have different characteristics in the regulatory regimes before and after deregulation.
There is relatively little empirical evidence with regard to the drivers of underwriting cycles. Lamm-Tennant/Weiss (1997) find a positive relationship between the change in real GDP, the

change in losses with lag 1 and 2, and underwriting cycles. Meier/Outreville (2006) find a positive relationship between the money market rate and underwriting cycles and a negative relationship between reinsurance prices and cycles for the German market. Maguhn (2007) develops a model that divides an underwriting cycle into eight phases and tests it for the period 1977–2000 for the German market. However, his focus is on explaining different phases of a cycle rather than the cycle length itself. On a by-line basis Berry-Stölzle/Born (2010b) analyze the effects of the 1994 deregulation and find that cyclical patterns as well as the factors influencing these patters vary across regulatory regimes. They conclude that changes in the regulatory environment are associated with a direct influence on cyclical behavior and an indirect effect on insurers' premium setting processes by changing the relative importance of other internal and external factors used for pricing decisions. Berry-Stölzle/Born (2010a) confirm the finding that factors influencing premium changes are different for the two time periods before and after deregulation and derive implications for insurance pricing. In highly competitive lines they find a significant price decrease after deregulation, but this decrease is offset by higher prices in other lines.

Berry-Stölzle/Born (2010b) also find that equalization reserves (Schwankungsrückstellung), which reduce variability in losses and thus smooth performance, have a moderating effect on premiums, but this effect decreases in the deregulated period after 1994. While Berry-Stölzle/Born (2010a, 2010b) focus on an analysis of the deregulation in 1994, we want to analyze cycle periods and premium changes over a long period of time (1957-2006). Furthermore, we cannot model equalization reserves since we have no such data available.

3 Methodology and Data

3.1 Methodology

3.1.1 Stationarity and Augmented Dickey Fuller test (ADF test)

If a nonstationary time series is involved in a linear regression, either as a dependent or independent variable, the regression could be spurious and the t and F-statistics invalid (see, e.g., Baltagi, 2008). For this reason, all time series used in our analysis are tested for stationarity using the Augmented Dickey Full test (ADF test). We include a constant and a time trend in the test equation, and determine the number of lags for the lagged difference term by the Akaike Information Criterion (AIC). Critical values for the t-statistic for the rejection of the null hypothesis of a unit root in the time series, i.e., nonstationarity, are taken from McKinnon (1991).

3.1.2 Existence and lengths of underwriting cycles

One frequently applied method to identify underwriting cycles is the AR(2) model, first proposed by Venezian (1985) and further developed by Cummins/Outreville (1987):

$$\Pi_t = a_0 + a_1\Pi_{t-1} + a_2\Pi_{t-2} + a_3 TIME_t + \omega_t \tag{1}$$

The underwriting profit in period t Π_t depends on the underwriting profits of the two previous periods and a random error term ω_t following a white-noise process. An additional variable reflecting a linear time trend is added to control for the downward trend in expenses over time. The advantage of this model is that it helps identify the parameters needed to verify the existence and length of underwriting cycles in competitive markets and under rational expectations; however, it does not discriminate among the different hypotheses as to *why* these cycles occur (see Meier/Outreville, 2006).

A cycle will be present if $a_1 \succ 0$, $a_2 \prec 0$, and $a_1^2 + 4a_2 \prec 0$. The length of the underwriting cycle period is then calculated as:

$$Period(P) = 2\pi / \cos^{-1}(a_1 / 2\sqrt{-a_2}) \tag{2}$$

In order to detect the right functional form, we compared autoregressive models with different numbers of time lags—AR(1), AR(2), and AR(3) processes—with trend variable and without trend variable. According to the adjusted R squared, the AR(2) model with trend variable best describes the development of underwriting profits over time.

3.1.3 Drivers of underwriting cycles

While we know that many insurance markets have switched between "hard" and "soft" markets over time, the economic value of having time-series estimates of the cycle length is limited if no additional information on the underlying drivers is provided. There is no physical law governing insurance markets that implies a particular time-series pattern in prices. Instead, there is a set of economic factors that account for the historical pattern in prices and understanding these economic factors is an important issue. Thus, the second focus of the paper is on the causes of underwriting cycles.

In order to investigate the factors driving underwriting cycles, the premium change analysis proposed by Lamm-Tennant/Weiss (1997) is used. This approach is based on the rational expectations/institutional intervention hypothesis and focuses on the relationship between premium changes and different market and institutional features. The underlying idea is that underwriting cycles directly act through premium changes, taking losses as exogenous. In accordance with Lamm-Tennant/Weiss (1997), we use a pooled cross-section time series regression model that controls for autocorrelation and heteroscedasticity:

$$\Delta P_{it} = \alpha + \sum_{j=1}^{J} \beta_j \Delta x_{jt} + \sum_{i=1}^{n-1} c_i D_i + \varepsilon_{it}, \quad (3)$$

where ΔP_{it} = change in premiums for line i and time period t (In [$Premiums_{it}$] - In [$Premiums_{it-1}$]), $\varepsilon_{it} = \rho\varepsilon_{i,t-1} + \mu_{it}$, $\mu_{it} \sim N(0, \sigma^2_{iu})$, n = the number of lines of business, and D_i = a dummy variable equal to one for line i and zero otherwise. Δx_{jt} is a vector containing the institutional and market variables displayed in Table 2. Year dummies are also included in the regression model to capture time effects.

Panel A of Table 2 sets out the variables used by Lamm-Tennant/Weiss (1997). Changes in one-year, two-year, and three-year lagged losses, as well as a regulation dummy variable, are included to account for regulatory, accounting, and data collection lags. Other variables are included to take into account the impact of interest rates (proxied by change of discount rate) as well as general economic development (proxied by change in real GDP) on premiums. Share prices (proxied by the change in stock index) are included to acknowledge the impact of changes in the price of capital on insurance supply. Concentration is an indicator of market power and may be positively related to premiums. As done in Lamm-Tennant/Weiss (1997) we consider the aggregate market share of the top-5 insurers according to premiums by-line. Premiums often rise significantly in the years following a catastrophic event and for that reason changes in catastrophic losses are included in the model. One variable used in the original model (policy period) is not included, as such data are not available on a by-line basis. Neither did we include the variable "reserves discount"; in Germany discounting was prohibited for all lines until 1998 and afterwards allowed for all lines.

We extend the model presented in Lamm-Tennant/Weiss (1997) by the factors set forth in Panel B of Table 2. The following additional macroeconomic variables were chosen to see whether they better explain premium changes than the commonly used real GDP: public expenditures, gross fixed investments, private consumption, employment, Consumer Price Index. The motivation for selecting these variables comes from Swiss Re (1989), which analyzes macroeconomic factors driving the development of the insurance industry, but does not consider the underwriting cycle. Additionally, we test some line-specific variables: production in the construction industry for homeowners and content; registration of new vehicles for motor; and oil price for motor and transport. These variables have been considered as major economic factors for these industries and our aim is to find whether these also affect underwriting cycles. Reinsurance prices are also included since they are indicative of insurance supply and thus may influence premiums and cycles (see Meier/Outreville, 2006).[1/2]

Variable	Variable Definition
Panel A: Variables from standard model	
$\Delta Loss_{1it}$	ln [$Losses_{i,t-1}$] - ln [$Losses_{i,t-2}$]
$\Delta Loss_{2it}$	ln [$Losses_{i,t-2}$] - ln [$Losses_{i,t-3}$]
$\Delta Loss_{3it}$	ln [$Losses_{i,t-3}$] - ln [$Losses_{i,t-4}$]
ΔDiscount $rate_t$	ln [Discount $rate_t$]- ln [Discount $rate_{t-1}$]
ΔShare $prices_t$	ln [Average share $price_t$]- ln [Average share $price_{t-1}$]
ΔReal GDP_t	ln [Real GDP_t]- ln [Real GDP_{t-1}]
$Concentration_{it}$	Aggregate market share of top-5 insurers
$Regulation_t$	0 until 1993; 1 after 1994
ΔCat_{t-2}	ln [Cat $losses_{t-2}$] - ln [Cat $losses_{t-3}$]
Panel B: Additional variables	
ΔPublic $expenditures_t$	ln [Public $expenditures_t$]- ln [Public $expenditures_{t-1}$]
ΔGross fixed $investment_t$	ln [Gross fixed $inv._t$]- ln [Gross fixed inv_{t-1}]
ΔPrivate $consumption_t$	ln [Private $consumption_t$]- ln [Private $consumption_{t-1}$]
$\Delta Employment_t$	ln [$Employment_t$]- ln [$Employment_{t-1}$]
ΔConsumer Price $Index_t$ (CPI_t)	ln [CPI_t]- ln [CPI_{t-1}]
ΔProduction in construction $industry_t$	ln [Prod. $construction_t$]- ln [Prod. $construction_{t-1}$]
ΔRegistration of new $vehicles_t$	ln [New $vehicles_t$]- ln [New $vehicles_{t-1}$]
ΔReinsurance prices	ln [Reinsurance $prices_t$]- ln [Reinsurance $prices_{t-1}$]
ΔOil $price_t$	ln [Oil $price_t$]- ln [Oil $price_{t-1}$]

Table 2: Market and institutional variables used in premium change equation

3.2 Data

We need underwriting profits to calculate underwriting cycles, information not easily obtained. However, in literature underwriting profits are typically proxied by loss ratios (losses divided by premiums) or combined ratios (premiums and expenses divided by losses). These are highly correlated with underwriting profits and more readily available (see, e.g., Outreville, 1990; Lamm-Tennant/Weiss, 1997; Meier/Outreville, 2006; see Adelman/Trieschmann/ Nicholson, 1980, for a discussion of profitability measurement in property-liability insurance). In our study we focus on loss ratios, since expenses data are available only after 1975, while loss data are available starting in 1955. We did additional tests using combined ratios (from 1975 onward); our findings are robust with regard to the choice of either loss ratios or combined ratios. This result is in line with Cummins/Nye (1984), who find that loss ratios are highly correlated with combined ratios.

In defining the loss ratio, literature uses either premiums divided by losses (e.g., Cummins/Outreville, 1987; Meier, 2006) or losses divided by premiums (e.g., Lamm-Tennant/Weiss, 1997). In principle, cycle lengths could differ depending on the definition

1 Additionally, we analyzed drivers of underwriting cycles using a cointegration approach suggested by Meier (2006) based on Engle/Granger (1987). Loss ratios are tested for cointegration, i.e., a long-term equilibrium relationship with the market and institutional variables also used in the premium change analysis. The results from the cointegration analysis confirm those of the premium change analysis. We also conducted tests for structural breaks as done, e.g., in Leng (2006) and Leng and Meier (2006). All these additional tests are available upon request.

2 Berry-Stölzle/Born (2010b) conduct a comparable premium change analysis over the period 1983 to 2004 to analyze the effects of the 1994 deregulation. In their model, they do not consider the factors presented in Panel B of Table 2. They consider equalization reserves that we cannot model since we have no such data available.

used. The underlying problem is comparable to discrete versus continuously compounding, i.e., the difference in cycle lengths between the two approaches is larger the larger the changes in loss ratios are. If calculations are based on logarithmized ratios, both approaches result in the same cycle lengths. We focus on loss ratios (losses divided by premiums), but additional tests show that the empirical results do not vary much if the alternative definition (premiums divided by losses) is employed instead.

We obtained data on premiums and losses for the German property-liability market and nine property-liability lines of business for the period of 1955–2006 from annual reports issued by the German regulator. The lines of business include motor, casualty, liability, legal, fire, transport, credit, content, homeowners.[3] Losses were corrected by amounts due to the processing of unsettled claims from the previous year, since this result only concerns historical claims, not claims from the actual year. Detailed descriptive statistics on the loss ratio data as well as various test statistics are reported in Appendix A. Here, we also describe the variables used as potential drivers for underwriting cycles.

4 Results

4.1 Estimation of Cycle Lengths

We first present detailed results from the underwriting cycle estimation using motor insurance as an example (see Table 3). Motor insurance was chosen as an example because it is the biggest line of business with 36% of total property-liability insurance premiums in 2006. Then we show summary statistics of the results for the whole property-liability market and all lines of business (see Table 4). Detailed results for individual lines of business are available from the authors upon request.

We are interested in the robustness of underwriting cycle with regard to the time horizon involved in the estimation. We thus consider a large number of meaningful subperiods in the underwriting cycle estimation. In order to determine these subperiods we combine different starting and end years, e.g., 1957-2006, 1958-2006, … (varying the starting years) or 1957-2006, 1957-2005, … (varying the end years). A subperiod was required to have at least 12 years of data, which is the shortest period analyzed in the underwriting cycle literature (see Outreville, 1990). The first column of Table 3 contains different starting points from 1957 to 1995. The first row shows different end points from 1968 to 2006, taking into account the minimum requirement of 12 years of data.[4] The number contained in Row 2 and Column 13 (marked by a box in Table 3) can be interpreted as follows: calculating the underwriting cycle starting in 1957 and ending in 1979 leads to an underwriting cycle length of 7.0 years.

Only 323 of the 780 subperiods display stationary time series and can thus be considered for cycle estimation using the AR(2) process. Cycle lengths in years are displayed. Nonstationary periods are marked "NSt" in Table 3.[5] Those periods for which the parameters a_1 and a_2 from Equation (1) are significant at the 10% level are shaded. With 178 of the 323 stationary cycle periods a_1 and a_2 are simultaneously significant at the 10% level. In the other cases, the a_2 parameter is mostly insignificant, while the a_1 parameter is highly significant.

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3 For legal, data were available only for 1957–2006; for content and homeowner insurance, the data were available only from 1974–2006.

4 Our data begin in 1955 and we consider an autoregressive process with lag 2, so the minimum starting year for our estimators is 1957. With 39 starting years and 39 end years available, we can create (((39 * 39) – 39)/2 + 39) = 780 possible subperiods for the period 1957–2006 with property-liability, motor, casualty, liability, fire, transport, and credit. As the data for content and homeowners starts in 1974, there are only 210 subperiods for these two lines. For legal insurance, there are 703 subperiods (the data starts in 1957).

5 It is also possible that time series are stationary, but that a cycle is not present if the conditions $a_1 \succ 0$, $a_2 \prec 0$, and $a_1^2 + 4a_2 \prec 0$ are not fulfilled. While this is not the case in motor insurance (Table 3), it is in some of the other lines (available from the authors upon request).

	End																																						
Start	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1957	NSt	NSt	NSt	NSt	7.9	NSt	NSt	NSt	NSt	NSt	NSt	7.0	NSt	7.2	7.1	7.1	7.1	6.4	6.3	6.5	6.7	NSt	7.5	8.8	8.4	8.9	8.9	NSt	NSt	NSt	9.9	9.5	9.3	8.9	9.0	NSt	NSt	NSt	NSt
1958		NSt	NSt	NSt	7.5	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	7.2	7.1	7.0	7.0	6.3	6.2	6.5	6.7	NSt	NSt	NSt	8.4	9.0	NSt	NSt	NSt	NSt	9.9	9.4	9.3	8.8	9.0	NSt	NSt	NSt	NSt
1959			NSt	NSt	7.1	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	7.1	7.1	6.4	6.3	6.6	6.9	NSt	NSt	NSt	8.6	9.3	NSt	NSt	NSt	NSt	9.9	9.4	9.2	8.8	8.9	NSt	NSt	NSt	NSt
1960				NSt	6.9	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	7.1	6.4	6.3	6.6	6.9	NSt	NSt	NSt	8.7	9.4	NSt	NSt	NSt	NSt	9.8	9.3	9.1	8.7	8.8	NSt	NSt	NSt	NSt
1961					6.9	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	7.1	6.4	6.3	6.6	7.0	NSt	NSt	NSt	8.5	9.1	NSt	NSt	NSt	NSt	9.4	8.9	8.8	8.4	8.5	9.8	NSt	NSt	NSt
1962						NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	7.0	6.4	6.3	6.6	6.8	NSt	NSt	8.8	8.1	8.4	8.4	NSt	NSt	9.9	8.8	8.4	8.3	8.0	8.1	9.1	NSt	NSt	NSt
1963							NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	6.4	6.3	6.5	6.8	NSt	NSt	NSt	7.9	8.2	NSt	NSt	NSt	9.6	8.6	8.3	8.1	7.8	7.9	8.9	NSt	NSt	NSt
1964								NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	6.3	6.5	6.8	NSt	NSt	NSt	7.9	8.1	NSt	NSt	NSt	NSt	8.4	8.1	7.9	7.7	7.7	8.6	NSt	NSt	NSt
1965									NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	8.3	8.0	7.8	7.6	7.7	8.5	NSt	NSt	NSt
1966										NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	8.1	8.0	7.7	7.5	7.6	8.3	NSt	NSt	NSt
1967											NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	8.1	7.9	7.7	7.5	7.6	8.3	NSt	NSt	NSt
1968												NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	7.9	7.7	7.5	7.4	7.4	8.0	NSt	NSt	9.7
1969													NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	7.7	7.6	7.4	7.3	7.3	7.9	NSt	NSt	NSt
1970														NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	7.5	7.4	7.3	7.2	7.2	7.7	NSt	NSt	NSt
1971															NSt	6.0	6.0	5.7	5.6	6.2	6.9	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	8.1	7.7	7.7	NSt	NSt	NSt	NSt
1972																NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	7.6	7.7	NSt	NSt	NSt	NSt
1973																	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	7.4	7.5	NSt	NSt	NSt	NSt
1974																		NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt	7.4	NSt	7.2	7.0	7.0	7.5	NSt	8.6	9.0
1975																			NSt	5.5	NSt	NSt	NSt	17.1	6.3	6.2	5.9	6.2	6.6	6.3	5.9	6.2	6.1	6.1	6.1	6.4	6.9	7.3	7.6
1976																				3.1	3.0	NSt	3.9	4.0	4.1	4.3	4.2	4.6	4.9	4.9	4.9	5.4	5.6	5.5	5.6	5.8	6.3	6.8	7.0
1977																					3.0	NSt	NSt	NSt	NSt	NSt	4.0	NSt	NSt	4.8	4.8	NSt	NSt	5.6	5.6	5.9	NSt	NSt	NSt
1978																						3.5	NSt	NSt	NSt	NSt	4.1	4.3	4.6	4.6	4.7	NSt	NSt	5.6	5.6	5.8	6.2	6.7	6.9
1979																							NSt	NSt	NSt	NSt	4.1	4.4	4.7	4.7	4.7	NSt	NSt	5.6	5.6	5.8	NSt	NSt	6.9
1980																								NSt	NSt	NSt	4.3	4.5	4.7	4.7	4.8	NSt	NSt	5.7	5.7	5.9	6.3	6.7	6.9
1981																									NSt	NSt	4.4	4.5	4.8	4.8	4.9	NSt	NSt	5.8	5.8	6.0	6.4	6.8	7.0
1982																										NSt	4.4	4.5	4.7	4.7	4.8	NSt	NSt	5.8	5.8	6.0	6.3	6.7	6.8
1983																											4.4	4.5	4.6	4.6	4.7	NSt	NSt	5.8	5.8	6.0	6.3	6.6	6.8
1984																												4.5	4.7	4.7	4.9	NSt	NSt	5.9	5.9	6.1	NSt	NSt	7.0
1985																													4.7	4.7	4.9	NSt	NSt	5.7	5.8	6.0	NSt	NSt	NSt
1986																														5.0	5.2	NSt	NSt	NSt	NSt	NSt	NSt	NSt	NSt
1987																															5.5	NSt	NSt	6.1	6.1	6.4	6.8	7.2	7.4
1988																																NSt	NSt	6.0	6.0	6.4	6.8	7.2	7.4
1989																																	NSt	5.9	5.9	NSt	NSt	NSt	7.5
1990																																		6.2	6.1	NSt	NSt	NSt	7.5
1991																																			6.4	NSt	NSt	NSt	NSt
1992																																				NSt	NSt	NSt	7.7
1993																																					NSt	NSt	NSt
1994																																						NSt	NSt
1995																																							8.5

NSt: underlying time series nonstationary; gray shade: cycle parameters significant at 10% level.

Table 3: Underwriting cycle lengths (in years) based on AR(2) process for German motor insurance market

Although it is not clearly stated in literature whether the parameters a_1 and a_2 need to be significant in order to get meaningful cycle lenghts,[6] we recommend to concentrate on those cycles that have this property, because otherwise we might find extreme outliers. For example in Table 3, cycle lengths range from 3.0 years for the period 1976–1988 to 17.1 years for the period 1975–1991. A 17-year cycle for a time series which is 16 years only does not seem too meaningful. If only the shaded stationary time series are considered the minimum is 4.83 years and the maximum is 9.95 years, which seems more reasonable.

However, even if the cycles are stationary, the problem remains that cycle lengths can change considerably just by adding another year of data to the time series. For example, the cycle length for the 40-year period from 1963 to 2002 is 7.9 years. Adding one more year of data (1963–2002) increases the cycle length to 8.9 years. Given this variability of results, we recommended to perform a sensitivity analysis for different time periods when analyzing underwriting cycles. Our empirical results illustrate that concentrating on only one time period (as done in nearly all existing studies on underwriting cycles) disregards the variation across time and this seems to be an important property of underwriting cycles.

The estimated cycle lengths for motor insurance are in line with results from studies covering other countries. For example, Cummins/Outreville (1987) find motor insurance cycles of 7.26 years for Sweden, 8.20 years for France, 5.17 years for Switzerland, and 5.72 years for the United States for the period 1957–1979. The cycle length for Germany from our study for this period is 7.0 years. Chen/Wong/Lee (1999) find motor insurance cycles of 7.70 years for the Singapore, 7.35 years for Japan, and 5.51 years for Taiwan for the period 1970–1995. The corresponsing cycle length for Germany is not available for the same time period, but amounts to 7.5 years for a similar period (1970–1998). We cannot directly compare the results from Lamm-Tennant/Weiss (1997) with our results on the German motor market, since they analyze only the motor-liability market and not the full market (motor-liability and own damage insurance). Their cycle is 5.47 years for the period 1965–1987. We cannot calculate any cycle for this period as the underlying time series is nonstationary. However, there is a cycle of 6.5 years for the period 1964–1987, which is roughly a year longer than the one found by Lamm-Tennant/Weiss (1997) for the motor-liability market.

In Table 4 summary statistics for the other lines of business are displayed. Panel A contains cycles for all periods with stationary underlying time series. In Panel B, summary statistics are displayed for all time series that are stationary *and* have cycle parameters significant at the 10% level when applying Equation (1).

Panel A of Table 4 shows that average cycles are 5.30 years for the whole property-liability market, with a minimum of 3.56 years and a maximum of 13.39 years. These results are in line with those of other studies on the German property-liability market (see Section 2.2). However, it is important to note that the number of time periods for which a cycle can be calculated is very low: only 66 periods. For all other possible periods, the time series are either nonstationary or the prerequisites for a cycle are not fulfilled.

For the individual lines of business, average cycle lengths range from 3.27 years (homeowners) to 7.45 years (credit). Most lines display average cycles between 6 and 8 years, which is in line with findings for other markets (see, e.g., Cummins/Outreville, 1987; Lamm-Tennant/Weiss, 1997). E.g., the finding that cycles are relatively short in homeowners is in line with Venezian (1985). For legal and homeowners, the standard deviation of cycle lengths is relatively low, but for other lines, standard deviations are high, which again shows the necessity of a sensitivity analysis with regard to the underlying time period.

[6] Most existing studies display cycle lengths irrespective of the significance of cycle parameters (see, e.g., Cummins/Outreville, 1987; Chen/Wong/Lee, 1999). The only study that excludes cycles in case of insignificant parameters is Meier/Outreville (2006).

Line of Business	Max. Number of Cycles	Number of Cycles	Mean	St. Dev.	Min	Max
Panel A: Cycle lengths (all stationary time series)						
Property-liability	780	66	5.30	1.80	3.56	13.39
Motor	780	323	6.84	1.58	2.97	17.11
Casualty	780	7	6.39	4.94	3.72	16.50
Liability	780	21	3.71	0.42	3.32	4.84
Legal	703	421	6.38	0.91	4.07	10.07
Fire	780	84	5.48	0.96	3.60	8.33
Transport	780	159	7.83	1.16	6.20	15.57
Credit	780	194	7.45	1.20	4.67	9.83
Content	210	2	4.46	0.29	4.26	4.66
Homeowners	210	185	3.27	0.09	2.73	3.49
Panel B: Cycle lengths (all stationay time series *and* cycle parameters significant at 10% level)						
Property-liability	780	0	/	/	/	/
Motor	780	178	7.15	1.20	4.83	9.95
Casualty	780	0	/	/	/	/
Liability	780	0	/	/	/	/
Legal	703	413	6.41	0.89	5.12	10.07
Fire	780	3	5.79	0.14	5.67	5.94
Transport	780	153	7.66	0.72	6.20	9.52
Credit	780	182	7.55	1.16	5.06	9.83
Content	210	0	/	/	/	/
Homeowners	210	12	3.18	0.07	2.97	3.28

Table 4: Summary statistics by-line of business on underwriting cycle lengths (in years)

Conducting a sensitivity analysis for different lines of business over a number of subperiods also provides us a new methodology for testing the capacity constraints hypothesis, which claims that underwriting cycles are most prominent in long-tail lines such as liability. If this hypotheses is true, we would expect to find more significant cycles for liability compared to the other lines of business. However, Panel A of Table 4 reveals no such pattern. For liability, there are only 21 cycles, which makes liability one of the lines for which the underwriting cycle is least prominent. We therefore cannot confirm the capacity constraint hypothesis.

Looking at Panel B of Table 4, we see that for the property-liability market as a whole and the separate lines of casualty, liability, and content, there are no time periods during which the stationarity and significance requirements are fulfilled. For fire and homeowners, there are very few cycles that qualify. In contrast legal, transport, and credit have nearly as many cycles in Panel B as they did in Panel A. The standard deviations of cycle lengths are lower for all lines in Panel B compared to Panel A, again indicating that the significance criterium reduces the variation of the results. Most particularly, the extreme maxima in motor (from 17.11 to 9.95) and transport (from 15.57 to 9.52) are reduced.

Considering the effect of deregulation on underwriting cycles, Lamm-Tennant/Weiss (1997) argue that under the institutional intervention hypothesis lines regulated more stringently will (ceteris paribus) have longer cycles as regulatory lags increase the delay between the experience period and the projection period. Consequentely, we should find shorter cycles in the German market after the deregulation in 1994. However, in our empirical results we cannot identify shorter cycles after 1994. E.g., in motor insurance cycles tend to be longer (see Table 3). One reason for this might be that the ceteris paribus condition is not fulfiled. E.g., we also experienced an increase in competition as well as the use of more sophisticated rate making methods since 1994. All these developments might influence cycle lengths and it is neither theoretically nor empirically clear whether the net effect on cycle lenghts is positive or negative. This result therefore highlights the complex interaction of the different reasons for underwriting cycles. To shed some more light on these interactions we analyze factors driving underwriting cycles in the next Section.

4.2 Analysis of Factors Driving Underwriting Cycles

As shown in the previous Section, both the existence as well as the length of the underwriting cycle is sensitive to the measurement period. And even if a cycle exists this does not imply that there is a law governing insurance markets to follow a certain time-series pattern. Rather there is a set of economic factors that should account for the historical pattern. Understanding these economic factors is the aim of this Section. This part of the paper extends two analyses of the effects of the 1994 deregulation in Germany (Berry-Stölzle/Born, 2010a, 2010b) by a consideration of a long period of time (1957-2006) and by involving additional factors that were denoted as premium relevant in Swiss Re (1989).

The generalized least square results from Equation (3) are displayed in Table 5. Results in Panel A are based on the same model as in Lamm-Tannant/Weiss (1997). The model has been extended by additional explanatory variables in Panel B. The second column in the table shows the aggregated results over all lines of business, while the subsequent columns show the results of the by-line regressions.[7] The last line of each panel gives the adjusted R squared. The variables “catastrophe losses” and “reinsurance prices” were tested separately as data on these variables are available for only relatively short time periods (1970–2006 and 1980–2006, respectively). They are insignificant in the regressions (see Appendix B).

We at first analyze the Lamm-Tennant/Weiss (1997) model for all lines of business (second column in Panel A). The change in losses with lags 1, 2, and 3 are significant in explaining premium changes in the German market. In the insurers' calculations, premiums are calculated as discounted future losses plus additional loadings for risk bearing and administration cost. For that reason, we expect a positive link between losses and premiums. And in fact, the signs are positive. Unlike Lamm-Tennant/Weiss (1997), however, we do not find any significant relationship between the change in real GDP and premium changes. It thus seems that premiums in the German insurance market are not directly linked to the general business cycle as found for the US. Also, the other explanatory variables (change in discount rate, share price, and concentration) are not significantly related to premium changes. We do find the regulation variable to be significant in general. As shown by the negative sign, deregulation leads to less severe premium changes.

Two more comprehensive analyses in this context that also document significant effects of deregulation in the German market are the studies by Berry-Stölzle/Born (2010a, 2010b). Note that the main focus of this part of our study is not on the effects of deregulation, but on an analysis over a long period of time (1957-2006) and involving other factors that were denoted as premium relevant in Swiss Re (1989). Comparing our results (Panel A, all lines) with the results in Berry-Stölzle/Born (2010b), we find consistent results with regard to losses and ΔReal GDP, while over our sample period results for ΔDiscount rate and ΔShare prices are not significant. In Panel A, we also document a significant negative effect of the deregulation variable for all lines, which is consistent with Berry-Stölzle/Born (2010b) finding that in general deregulation affects premium changes.

[7] The data on the whole property-liability market has been excluded from this analysis. Instead, as done in Lamm-Tennant/Weiss (1997), we consider an aggregation over all nine lines of business as a proxy for the whole market. This gives us 392 observations of the dependent variable (premium change). For the by-line regressions, there are only 48 observations of the dependent variable for each line, except for legal (46 observations) and contents and homeowners (29 observations each). Results of spefication tests (heteroskedasticity and autocorrelation of the residuals) for each regression and cross-correlations between the residuals of the different regressions (with regard to diversification issues) are available upon request.

	All Lines	Motor	Casualty	Liability	Legal	Fire	Transport	Credit	Content	Homeowners
Panel A: Standard model (Lamm-Tennant/Weiss, 1997)										
Adjusted R squared	0.49	0.73	0.44	0.75	0.83	0.37	0.27	0.31	0.73	0.23
Intercept	3.22***	-2.70	3.53*	3.38	7.36**	3.10	0.74	3.69	9.06*	9.75**
ΔLoss1	0.10**	0.58***	-0.03	0.22**	0.12*	0.08	0.14	0.10*	0.08	0.06**
ΔLoss2	0.09***	0.28***	-0.10	0.13	0.10	0.29**	0.00	0.12**	0.03	0.02
ΔLoss3	0.04***	0.05	0.10	-0.18	0.05	0.22**	0.03	0.05	-0.04	-0.04
ΔDiscount rate	0.00	0.00	0.00	0.03	-0.03	-0.01	-0.11*	0.00	-0.01	-0.03
ΔShare prices	-0.01	-0.02	0.01	-0.01	0.00	0.01	-0.03	-0.02	0.00	-0.01
ΔReal GDP	0.23	0.80*	-0.37	-0.09	0.39**	0.16	0.36	0.73	-0.18	-0.38**
Concentration	0.04	0.17	0.13	0.08	-0.06	0.59	0.18	-0.56**	0.68*	-0.06
Regulation	-0.01*	-0.02	-0.05**	-0.02	0.01	0.02	-0.06*	0.03	0.03	0.02
Panel B: Extended model with additional variables										
Adjusted R squared	0.53	0.71	0.52	0.86	0.88	0.40	0.41	0.40	0.90	0.71
Intercept	2.69***	-3.52	4.92**	4.16***	5.66	2.58	-1.75	5.54	9.53**	12.13**
ΔLoss1	0.07*	0.72**	-0.13	0.06	0.08	0.01	-0.08	0.15***	-0.03	0.01
ΔLoss2	0.08***	0.41**	-0.14	0.04	0.09*	0.24**	-0.05*	0.15**	-0.02	-0.04
ΔLoss3	0.04***	0.02	0.12	-0.18*	0.07	0.12	0.01	0.03	-0.03	-0.09**
ΔDiscount rate	-0.03	0.02	-0.04	0.00	-0.05	0.04	-0.13**	-0.11	-0.04*	-0.11
ΔShare prices	0.01	-0.02	0.00	0.02	0.02	0.02	-0.03	0.02	0.03**	0.10**
ΔReal GDP	-0.21	0.35	-1.38	-0.84***	0.18	0.53	0.15	0.36	-1.11	0.46
Concentration	0.05*	0.24	0.16	0.03	-0.06	1.15	0.20	-0.17	0.57*	0.02
Regulation	0.01	-0.02	-0.03	0.01	0.02	0.03	-0.05*	0.05	0.05**	0.07
ΔPublic expenditures	0.24	-0.07	-0.49	0.32**	0.55***	1.45***	0.23	-0.83*	0.63***	1.42***
ΔGross fixed investment	-0.03	-0.27	0.59*	-0.30	-0.01	-0.16	0.60	0.16	0.00	-1.49**
ΔPrivate consumption	0.54*	-0.24	0.38	0.56*	0.40	-0.18	1.52*	1.12	-0.11	0.75
ΔEmployment	0.64*	0.45	-0.37	1.14***	0.35	0.09	-0.62	3.19	0.97	0.66
ΔProduction in construction	0.08	0.13	-0.08	0.30***	-0.01	0.25	-0.49*	-0.41	0.23**	0.82**
ΔCPI	1.06***	-0.34	1.26**	0.78**	0.71**	-0.14	1.76**	1.64	0.93***	1.00
ΔRegistration new vehicles	-0.01	0.22*	0.12	0.01	0.01	-0.25	-0.17*	-0.10	-0.01	0.06
ΔOil price	0.00	0.02	0.01	0.00	-0.01	-0.10*	-0.01	0.06	0.01	0.07

Note: * (**, ***) indicates significance level of 10% (5%, 1%).

Table 5: Results of premium change analysis

The adjusted R squared is 0.49 indicating that about half of the variance in premium changes can be explained by the model. This value is smaller than in Lamm-Tennant/Weiss (1997). However, we aggregate results across different lines of the property-liabilty industry while Lamm-Tennant/Weiss (1997) aggregate results across different countries. This finding thus again confirms Swiss Re (2001) – there is much more variation across lines than across countries, i.e., the correlation across lines is lower than across countries.

To improve the explanatory power we incorporate additional variables in the model. Results are presented in Panel B.[8] The adjusted R squared increases from 0.49 to 0.53. In comparison to the standard model, the change in the CPI is highly significant. The change in private consumption, employment, and concentration are also positively related to premium changes. Compared to the results presented by Lamm-Tennant/Weiss (1997) and Chen/Wong/Lee (1999), it seems that the CPI as a macroeconomic variable is a better explanation of premium changes in the German insurance market than is the real GDP.

Looking at the by-line results for the Lamm-Tennant/Weiss (1997) model, we see that changes in lagged losses are significant in explaining premium changes for most lines. The change in discount rates is significant only for transport, and share prices are not significant at all. In some lines, the change in real GDP is positively and significantly related to premium growth, e.g., in motor and legal. A negative sign is found for homeowners. The concentration and regulation variables are significant in only two cases each: credit and content for concentration; casualty and transport for regulation. Due to the 1994 deregulation of the German insurance market and ongoing consolidation (see Eling/Luhnen, 2008), we would have expected a significant impact for more lines of business. Again, we refer to Berry-Stölzle/Born (2010a, 2010b) for a more comprehensive analysis of the effects of deregulation.

Extending the standard model improves the adjusted R squared in the by-line regressions for all lines of business except motor.[9] The change in CPI, as well as public expenditures, are good explanations of premium change for most lines and replace real GDP as the main macroeconomic explanatory variable. This result confirms the finding that the CPI is more important in explaining premium growth in the German insurance market than the GDP. Furthermore, we discovered several line-specific variables: The registration of new vehicles is positively related to premium growth in motor insurance, which makes much sense given that motor insurance is obligatory for all new vehicles in Germany. We also find a positive connection between new vehicles and transport insurance. A positive development of construction leads to rising premiums in liability, transport, content, and homeowners insurance. Premium changes in liability insurance can be explained by the change in employment, which might be related to the demand for workers' compensation insurance. The variables "oil price," "gross fixed investment," "private consumption," "concentration," and "regulation" have only minor explanatory power for by-line premium changes.

Overall it seems that premium changes and underwriting cycles in the German market are mostly driven by demand side factors such as GDP or CPI rather than by supply side factors such as interest rates or stock prices. Lagged losses are also of high importance, as they drive both insurance supply and demand. The result that the capacity constraints hypothesis does not empirically fit for the German market also confirms this finding, because this hypothesis concerns the supply side.

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8 As mentioned above, the selection of the additional variables is motivated by Swiss Re (1989), which analyzes macroeconomic factors driving the development of the insurance industry, but does not consider the underwriting cycle. We also include line-specific variables such as registration of new vehicles for motor in order to identify major ecomic factors influencing selected lines of business.

9 In Table 5 all variables are included in the regression analysis. We also conducted a stepwise regression in order to identify the model with the highest adjusted R squared. Using backward elimination, the adjusted R squared increases on average (across the 10 models presented in Table 5) by 12% from 0.63 to 0.69. Although the regression presented in Panel B of Table 5 contains many variables, we decided to present the full model, because stepwise regression is often criticized for its data dredging nature.

5 Conclusion

The aim of this paper was to provide a comprehensive analysis of underwriting cycles in German property-liability insurance. In a first step, cycles were estimated for the whole market as well as for nine lines of business covering the period 1957–2006 and a large number of meaningful subperiods. We find that average cycles are 5.30 years for the whole property-liability market. The minimum is 3.56 years and the maximum 13.39 years, depending on the time period analyzed. For the individual lines of business, average cycle lengths range from 3.27 years (homeowners) to 7.45 years (credit). Most lines display average cycles between 6 and 8 years, which is in line with the existing literature on other markets (see, e.g., Cummins/Outreville, 1987; Lamm-Tennant/Weiss, 1997). However, the differences found, e.g, between homeowners and credit insurance emphasizes the relevance of a line specific analysis of underwriting cycles instead of analyzing the full market as done in much of the existing literature. Furthermore, the differences found for different time periods emphasize the relevance of a sensitivity analysis with regard to the investigation period. One of the advantages of this sensitivity analysis is that it provides a test of the capacity constraints hypothesis. This hypothesis which postulates that underwriting cycles are most prominent in long-tail lines cannot be confirmed in our empirical analysis.

The analysis of factors driving underwriting cycles showed that the model proposed by Lamm-Tennant/Weiss (1997) has some explanatory power for the German property-liability market. Changes in losses with lags 1, 2, and 3 are significant in explaining premium changes; however, other variables, such as real GDP, interest rates, or market concentration, are not. The results are also broadly in line with the premium change analysis by Berry-Stölzle/Born (2010a, 2010b) that focuses on the effects of deregulation in the German market. An extension of the Lamm-Tennant/Weiss (1997) model increases the explanatory power. The Consumer Price Index is highly significant in explaining premium changes and seems to be more appropriate than real GDP as a macroeconomic variable in the model. There is also some line-specific evidence with regard to selected economic variables. Registration of new vehicles is positively related to premium changes in motor insurance. A positive change in the production in construction leads to a positive change in premiums for content and homeowners insurance. Premium changes in liability insurance are also explained by change in construction and changes in employment.

Our results should help to deepen the understanding of the German property-liability insurance and provide insights for both researchers and practitioners. The broad evidence on cycle lengths for different lines of business can be used in enterprise risk management, solvency models and analyzing market scenarios. The same applies to the general and line-specific factors that we identified as drivers of underwriting cycles. Due to our sensitivity analysis on cycle lengths for different time periods, researchers and practitioners can assess the stability of a specific cycle length number used in their analyses.

As mentioned, there are two schools of thoughts on why underwriting cycles occur. One says they are due to the irrational behavior of insurers, the other states that such cycles are due to external factors that influence the behavior of rational insurers. Both approaches rely on assumptions about how decision making is conducted in an insurance company. One of the key assumptions in the models considered here is that only the variables from last year (or the last three years with the losses) are relevant in forming expectations. However, this might not necessarily reflect real-world decision making. In reality, the experience of more than one or three years influences expectations and it makes a difference whether there were extreme events in the recent past. Various forecasting approaches can be used to form expectations based on historical experience (see, e.g., Gould et al., 2008; Nikolopoulos et al., 2007). Researchers might use these approaches to provide more insight into the connection between decision making and insurance prices. An interesting avenue for future research, therefore, might be to conduct regressions on a rolling basis in order to improve the explanatory power of the models. This might improve our understanding of the dynamics in insurance markets, including the cyclical patterns analyzed in this paper.

Appendix A: Descriptive Statistics
Appendix A.1. Loss Ratio Data

The descriptive statistics in Table A1 illustrate that loss ratios tend to be higher in motor insurance compared to the whole property-liability market. In casualty, loss ratios are relatively low. The standard deviation of the loss ratios indicates the variability of losses in different lines of business. It is relatively low in casualty (3.9%), but higher in credit (25.7%) and homeowners (17.3%) insurance. The variation coefficient shows that the high variability is chiefly due to the volatility of the losses in credit: The variation coefficient of the losses is much higher than the variation coefficient of the premiums. For homeowners insurance, the high variability is mostly due to the volatility of the premiums, as the variation coefficient of the premiums is higher here than the variation coefficient of the losses.
The last two columns of Table A1 provide an overview of the results of the ADF test for unit roots in the loss ratio time series.[10] As discussed in Section 3.1., stationary time series are necessary for calculating underwriting cycles based on the AR(2) model. First, we tested whether the longest available time series is stationary for each line of business and the full property-liability market (see column 7 in Table A1). Transport, credit and homeowners are the only lines of business that show stationary time series for the longest available period.
We next tested whether the time series observed over selected subperiods are stationary. In order to determine a large number of meaningful subperiods we combine different starting and end years, e.g, 1957-2006, 1958-2006,… (varying the starting years) or 1957-2006, 1957-2005,… (varying the end years; see Section 4.1 for more details on the definition of the subperiods). The last column of Table A1 displays the portion of stationary subperiods in all subperiods. Motor, legal, and homeowners have a high percentage of stationary subperiods, whereas in the full market, casualty, and content there only are a few.
The high variability of the loss ratios in credit and homeowners insurance looks even more startling in Figure A1, which plots the loss ratios for the whole property-liability market as well as for the different lines of business. Figure 1 makes it especially apparent that there is a cyclical pattern in the development of the loss ratio for motor, transport, and credit insurance. However, in casualty and content insurance, no such pattern can be seen.

[10] Time series have been considered as stationary if the null hypothesis of the existence of a unit root has been rejected at the 10% level.

Line of Business	Data Available		Mean	Standard Deviation	Variation Coefficient	Stationary	% of Stationary Subperiods
Property-liability (full market)	1955-2006	Premiums	24,694,093	20,589,686	83.4%		
		Losses	19,233,887	16,360,264	85.1%		
		Loss Ratio	73.4%	8.2%	11.2%	No	8.5%
Motor	1955-2006	Premiums	10,079,451	8,086,525	80.2%		
		Losses	9,176,405	7,589,672	82.7%		
		Loss Ratio	85.3%	10.4%	12.2%	No	41.4%
Casualty	1955-2006	Premiums	2,244,349	2,135,408	95.1%		
		Losses	1,182,390	1,175,886	99.4%		
		Loss Ratio	52.5%	3.9%	7.4%	No	0.9%
Liability	1955-2006	Premiums	2,840,816	2,562,195	90.2%		
		Losses	2,150,013	1,970,621	91.7%		
		Loss Ratio	72.4%	7.3%	10.1%	No	2.7%
Legal	1957-2006	Premiums	1,203,125	1,075,773	89.4%		
		Losses	862,872	827,260	95.9%		
		Loss Ratio	61.4%	13.3%	21.7%	No	59.9%
Fire	1955-2006	Premiums	1,538,798	788,813	51.3%		
		Losses	1,161,180	673,971	58.0%		
		Loss Ratio	71.4%	14.2%	19.9%	No	10.8%
Transport	1955-2006	Premiums	827,907	463,962	56.0%		
		Losses	578,043	317,199	54.9%		
		Loss Ratio	70.8%	6.0%	8.5%	Yes	20.4%
Credit	1955-2006	Premiums	399,940	396,421	99.1%		
		Losses	319,599	359,517	112.5%		
		Loss Ratio	64.5%	25.7%	39.9%	Yes	24.9%
Content	1974-2006	Premiums	1,640,751	713,786	43.5%		
		Losses	928,042	340,013	36.6%		
		Loss Ratio	59.1%	6.7%	11.4%	No	1.0%
Home-owners	1974-2006	Premiums	1,994,551	1,306,038	65.5%		
		Losses	1,311,929	800,670	61.0%		
		Loss Ratio	76.3%	17.3%	22.6%	Yes	88.1%

Note: Premiums and losses are in thousands of Euros.

Table A1: Premiums, losses, and loss ratios in German property-liability insurance 1955-2006

Figure A1 also illustrates that consideration of industry-wide volume numbers might lead to the problem that the results are dominated by the biggest lines in an industry and that characteristics of small lines are ignored. For example, the correlation between the loss ratios of motor (the biggest line in German property-liability industry) and the full market is 0.96. For transport, the correlation of the loss ratio with the loss ratio of the full market is only 0.10 and for casualty it is actually negative (–0.45). This finding is in line with Swiss Re (2001), which finds that the by-line correlation is much lower than the correlation among different countries.

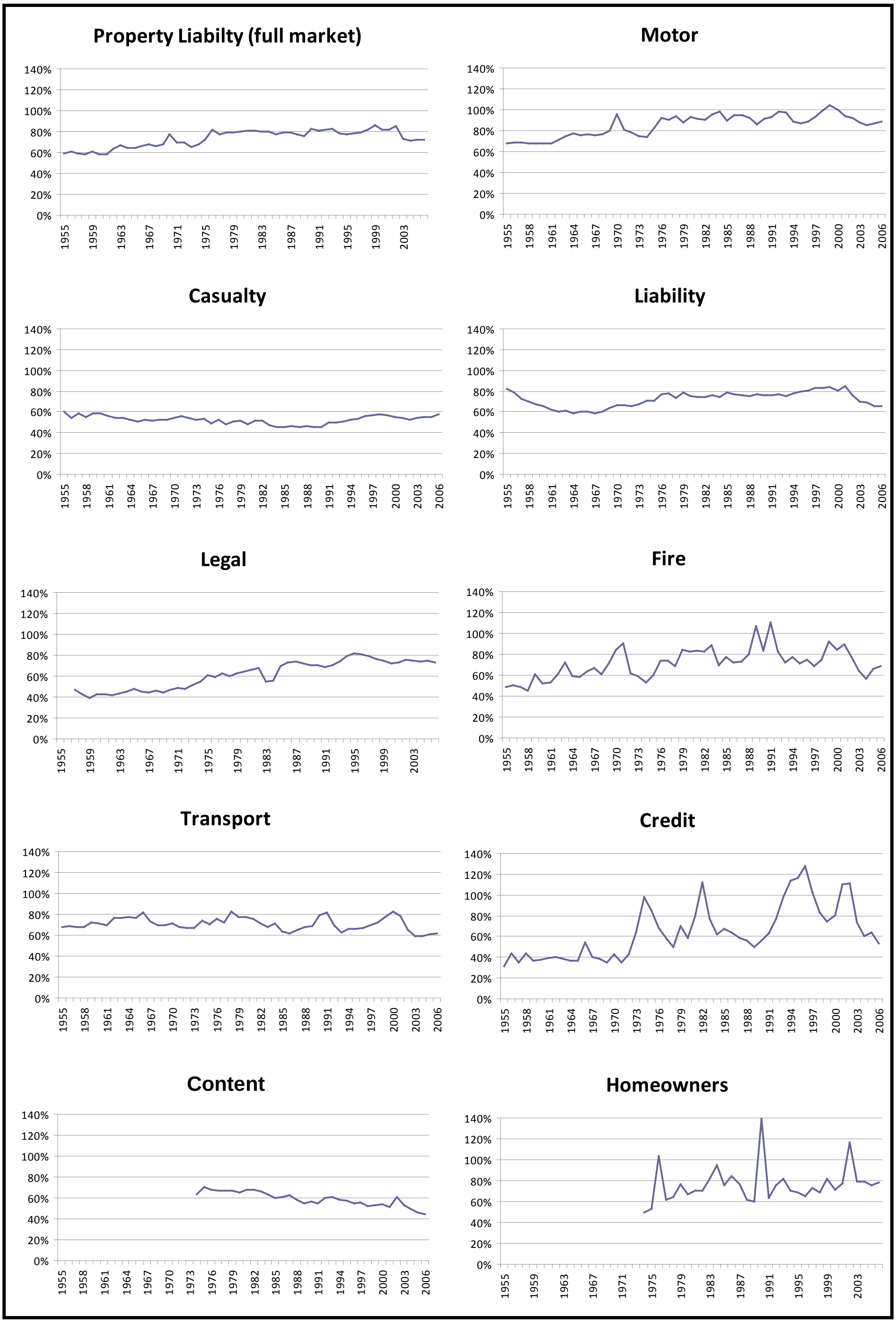

Figure A1: Loss ratios in German property-liability insurance 1955–2006

Appendix A.2. Variables used as potential factors driving underwriting cycles

Summary statistics for the variables used as potential factors driving underwriting cycles are presented in Table A2.[11] Data were obtained from the German Central Bank, except for the Reinsurance Price Index and the catastrophic losses, which were obtained from Swiss Re. The top-5 concentration ratios by-line were calculated based on premium data obtained from the German regulator. All time series have been tested for unit roots, and most have been found nonstationary. However, the variables have been included as differences into the premium change analysis in order to generate stationary time series for the regressions.[12]

Variable	Unit	Data Available	Mean	St.Dev.	Min	Max
Discount rate	%	1957–2006	6.65	1.67	3.30	9.90
Stock prices	Index	1959–2006	1773.41	1903.48	333.36	6958.14
Real GDP	Index	1957–2006	64.77	25.23	22.57	106.08
Catastrophic losses	USD millions	1970–2006	584.96	452.73	66.34	2085.84
Public expenditures	Index	1957–2006	70.54	24.05	24.83	102.72
Gross fixed investment	Index	1957–2006	66.80	19.85	30.28	100.00
Private consumption	Index	1957–2006	65.82	25.12	23.38	102.49
Employment	Millions	1957–2006	34.89	2.69	31.00	39.32
CPI	Index	1957–2006	65.67	27.34	28.20	110.10
Production in construction industry	Index	1957-2006	87.59	15.64	48.20	120.50
Registration of new vehicles	Millions	1957–2006	2.44	0.93	0.56	4.16
Reinsurance prices	Index	1980–2006	0.94	0.17	0.71	1.24
Oil price	USD	1957–2006	31.52	21.29	9.38	90.46
Concentration (top 5)						
P/L market	%	1965–2006	0.27	0.03	0.23	0.35
Motor	%	1965–2006	0.31	0.02	0.28	0.36
Casualty	%	1965–2006	0.41	0.04	0.34	0.51
Liability	%	1965–2006	0.37	0.03	0.31	0.43
Legal	%	1965–2006	0.61	0.16	0.44	1.00
Fire	%	1965–2006	0.37	0.02	0.32	0.40
Transport	%	1965–2006	0.41	0.08	0.29	0.58
Credit	%	1965–2006	0.91	0.05	0.81	0.97
Content	%	1975–2006	0.28	0.02	0.25	0.32
Homeowners	%	1975–2006	0.35	0.05	0.30	0.44

Table A2: Summary statistics on institutional and market variables

[11] We need to adjust some of the time series to control for the effects of the German reunification, e.g., in employment. In these cases, the values before 1990 were multiplied by the 1990 growth factor (value for 1990/value for 1989) to eliminate the extraordinary jump in the time series.

[12] We also checked for multicollinearity among the variables, but did not find any alarming evidence thereof.

Appendix B: Premium Change Analysis with Catastrophes and Reinsurance Price Index

	All Lines Without Additional Variables (N = 392)	**All Lines With Catastrophes** (N = 294)	**All Lines with Reinsurance** (N = 234)
Panel A: Standard model (Lamm-Tennant/Weiss, 1997)			
Adjusted R squared	0.49	0.49	0.40
Intercept	3.22***	2.97**	1.18
ΔLoss1	0.10**	0.11***	0.06**
ΔLoss2	0.09***	0.11***	0.11***
ΔLoss3	0.04***	0.05**	0.06**
ΔDiscount rate	0.00	0.00	-0.01
ΔShare prices	-0.01	-0.01	0.00
ΔReal GDP	0.23	-0.12	0.12
Concentration	0.04	0.02	0.01
Regulation	-0.01*	-0.02	-0.02*
Catastrophes	/	0.00	/
Reinsurance price	/	/	0.03
Panel B: Extended model with additional variables			
Adjusted R squared	0.53	0.50	0.45
Intercept	2.69***	0.43	0.18
ΔLoss1	0.07*	0.09***	0.05**
ΔLoss2	0.08***	0.11***	0.10***
ΔLoss3	0.04***	0.05**	0.04
ΔDiscount rate	-0.03	-0.01	0.00
ΔShare prices	0.01	0.00	0.03**
ΔReal GDP	-0.21	-0.17	0.92**
Concentration	0.05*	0.02	0.01
Regulation	0.01	-0.02	-0.02
ΔPublic expenditures	0.24	0.34	0.40
ΔGross fixed investment	-0.03	-0.08	-0.61***
ΔPrivate consumption	0.54*	0.10	-0.28
ΔEmployment	0.64*	0.50	0.29
ΔProduction in construction	0.08	0.01	0.18
ΔCPI	1.06***	0.77**	0.39
ΔRegistration new vehicles	-0.01	0.01	0.04
ΔOil price	0.00	0.00	0.02
Catastrophes	/	0.00	/
Reinsurance price	/	/	0.02

Table A3: Results of premium change analysis with catastrophes and reinsurance price index

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