HOW DO THE INTEREST RATE AND THE INFLATION RATE AFFECT THE NON-LIFE INSURANCE PREMIUMS?[1]

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Abstract:

This paper proposes an original framework based on nonlinear panel data models to study the empirical influence of the interest rate and the inflation rate on the non-life insurance premiums for fourteen developed countries over the period 1965-2008. More specifically, we apply the panel smooth transition error correction model which takes into account both the short and long-run effects of changes in economic variables on the growth rate of non-life insurance premiums and which allows the regression coefficients to vary across countries and over time.

Our empirical results show that the interest rate and the inflation rate have a differentiated impact on the non-life insurance premiums depending on the value of the inflation rate. These empirical findings provide evidence of changes in insurance pricing rules.

Keywords: non-life insurance premiums, interest rate, inflation rate, panel smooth transition error correction model and insurance pricing rules.

1. INTRODUCTION

The influence of the economic conjuncture on the non-life insurance industry has been widely examined in the literature[4] and numerous empirical studies have been developed in order to investigate the relationship between non-life insurance premiums and several economic variables like the interest rate and the consumer price index (or the inflation rate) in different countries.

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[4] For a literature review of the effect of the economic conjuncture and the financial conjuncture on the non-life insurance industry, see Sghaier (2011).

Understanding the relationship between non-life insurance premiums and the economic variables is important for setting the appropriate pricing levels especially in competitive markets, for forecasting the profitability and for monitoring the dependence between the underwriting risk and the market risk from a regulatory point of view. From the latter point of view, one of the recommendations in Solvency 2 emphasizes the importance of incorporating all the risks, including the inflation risk and the interest rate risk, when imposing the solvency capital rules.

In practice, some authors found that fluctuations in non-life insurance premiums (or measures of underwriting profits[1]) are related to the variations in the interest rate (Doherty and Kang (1988), Fields and Venezian (1989), Smith (1989), Fung et al. (1998), Choi et al. (2002), Fenn and Vencappa (2005) and Adams et al. (2006)), while other authors showed that the fluctuations in non-life insurance premiums are not related to the variations in the interest rate (Niehaus and Terry (1993), Lamm-Tennant and Weiss (1997), Chen et al. (1999) and Meier and Outreville (2006, 2010)).

Few authors have documented the impact of the inflation rate on the non-life insurance industry. D'Arcy (1982) found that underwriting profits are correlated with the inflation rate. Eling and Luhnen (2008) also found that fluctuations in non-life insurance premiums are related to the inflation rate. Krivo (2009) found that the relationship between underwriting profits and the inflation rate is time-varying: over the sub-period 1951-1976, the relationship is negative, while over the sub-period 1977-2006, the relationship is positive.

Otherwise, some authors found a cointegration relationship between non-life insurance premiums (or measures of underwriting profits) and the interest rate (Haley (1993, 1995, 2007) and Bruneau and Sghaier (2008)) and/or the consumer price index (Grace and Hotchckiss (1995), Blondeau (2001) and Meier (2006)), whereas other authors found that this relationship does not hold at all times. In particular, Leng et al. (2002) found that underwriting profits and investment income are not cointegrated over the sub-period 1958-1981, while they are negatively cointegrated over the sub-period 1983-1999. Leng and Meier (2006) also found evidence of a cointegration relationship only after the structural break in four countries.

The lack of consensus seems to be related to the fact that the authors apply linear models (linear regression model and linear error correction model) which assume that the

[1]By measures of underwriting profits, we mean underwriting profits, (economic) loss ratio, combined ratio...

relationship between the variables is stable over the period. This assumption seems to be restrictive due to the presence of structural breaks and the existence of regime change.

To allow for the structural breaks and the regime change, an alternative approach based on the smooth transition regression model, which supposes that the transition from one regime to another is related to an exogenous variable, has been applied. More specifically, Higgins and Thistle (2000) employed a smooth transition regression model to examine the influence of the interest rate on underwriting profits but they found no significant relationship between the variables. In the same context, Bruneau and Sghaier (2009a) considered a smooth transition regression model to examine the influence of the economic variables on the combined ratio. They concluded that the combined ratio is not affected by the interest rate. The main limitation of these two studies is that they used stationary variables, so they detect only the short-run dynamics.

Two later studies, Jawadi et al. (2009) and Bruneau and Sghaier (2009b) considered nonstationary variables and adopted an alternative approach based on nonlinear cointegration. More precisely, Jawadi et al. (2009) found evidence of a nonlinear cointegration relationship between non-life insurance premiums, the stock market index and the interest rate for three countries (United States, Japan and France), while Bruneau and Sghaier (2009b) found evidence of a nonlinear cointegration relationship between non-life insurance premiums and the consumer price index for the same countries.

Although these studies provide a comparative analysis of the relationship between non-life insurance premiums and the economic variables in an international framework, they employed individual time series models and made the estimation country by country. The shortcoming of the individual time series models is that they do not account for the homogeneity and the heterogeneity that may exist. To overcome this problem, we adopt a panel data approach. The advantage of this approach is not only to obtain more data but also to increase the power of the econometric tests (the unit root tests, the cointegration tests and the linearity tests, etc).

Although, several authors have applied panel data approach (Lamm-Tennant and Weiss (1997), Chen et al. (1999), Fenn and Vencappa (2005), Adams et al. (2006) and Eling and Luhnen (2008)), they have considered stationary series and thus studied only the short-run dynamics. Moreover, they considered panel linear models which suppose that the parameters are stable over the time. As in time series framework, these assumptions are restrictive because the parameters of the panel models are time-varying.

In this paper, we propose an alternative approach based on nonlinear panel data models, to study the impact of the economic variables, represented by the interest rate and the consumer price index, on non-life insurance premiums for fourteen developed countries. The advantage of this approach is to allow for both cross-country heterogeneity and time-instability of the coefficients.

More precisely, we consider the variables in levels and we adopt a panel nonlinear cointegration approach. In particular, we estimate a panel smooth transition error correction model that allows the presence of two extreme regimes, which are associated to the lower and the higher values of the transition variables and which supposes that the transition from one regime to another is smooth.

The presence of nonlinearities can be justified by, amongst others things, the existence of heterogeneous behaviours of insurers (Winter (1991)), the heterogeneous expectations of the insurers (Harrington and Danzon (1994) and Harrington et al. (2008)) and asymmetric information problems (Dionne and Harrington (1992), Dionne and Doherty (1992, 1994) and Dionne et al. (2011)).

The remainder of the paper is organized as follows. In section 2, we specify the model considered. In section 3, we describe the econometric methodology adopted. In section 4, we present the data and the empirical results. In section 5, we conclude the paper.

2. MODEL SPECIFICATION

In this paper, we aim at investigating the influence of the interest rate and the consumer price index on the non-life insurance industry for a panel of fourteen developed countries. The endogenous variable is the volume of non-life insurance premiums[1]. Formally, we consider the following specification:

$$lpn_{it} = \phi_i + \theta_{1i} intn_{it} + \theta_{2i} lipc_{it} + z_{it}. \tag{1}$$

Where $i = 1,...,N$ denotes the country, $t = 1,...,T$ denotes the time, lpn_{it} represents the logarithm of the non-life insurance premiums, $intn_{it}$ is the interest rate and $lipc_{it}$ is the logarithm of the consumer price index. ϕ_i denotes an individual fixed effect that is specific for each country i and z_{it} is an error term assumed to be $iid\left(0,\sigma^2\right)$.

If we assume that the interest rate and the consumer price index have the same impact on the non-life insurance premiums across the N countries of the panel, that is, we

[1]The ideal data would include the number of contracts and the price of each contract in order to distinguish between the volume and the price effects. However, these data are not available. So, we consider the volume of premiums.

suppose that $\theta_{1i} = \theta_1$ and $\theta_{2i} = \theta_2$ $\forall i = 1,...,N$. This choice is justified by the fact that preliminary individual time series regressions of the Equation (1) show that some countries share common similarities concerning the effect of the economic variables on the non-life insurance premiums[1].

Consequently, we obtain the following model:

$$lpn_{it} = \phi_i + \theta_1 intn_{it} + \theta_2 lipc_{it} + z_{it}. \tag{2}$$

The coefficient θ_1 represents the effect of the interest rate on the volume of non-life insurance premiums and the coefficient θ_2 can be interpreted as the elasticity of the volume of non-life insurance premiums with respect to the consumer price index.

If we refer to the financial models for insurance pricing (like the insurance capital asset pricing model, the discounted cash flow model and the option pricing model[2]) and to the underwriting cycles theories which try to determine the factors explaining the fluctuations of non-life insurance premiums (especially the rational expectation/institutional intervention hypothesis[3] which assumes that the fluctuations of non-life insurance premiums are explained by the factors that are exogenous to the insurance industry such as the interest rate, the consumer price index, the stock market return and the gross domestic product), we expect a negative sign for the coefficient θ_1 whereas the sign of the coefficient θ_2 is expected to be positive.

3. ECONOMETRIC METHODOLOGY

Like in the time series context, the first step of the econometric methodology in the panel data framework is to ascertain whether the series are nonstationary in levels. Then, we proceed to the panel cointegration tests. If the series are found to be cointegrated, we estimate the long-run relationship and we deduce the linear error correction model describing the dynamics of the growth rate of non-life insurance premiums. Finally, we propose a new approach for modelling the growth rate of non-life insurance premiums based on the panel smooth transition error correction model.

[1]In this paper, we do not report the empirical results for the regressions country by country but they are available upon request from the authors.

[2]For a detailed description of these models, see Cummins (1990, 1991).

[3]For a complete description of this hypothesis, see Lamm-Tennant and Weiss (1997), Harrington (2004) and Weiss (2007).

3.1 Panel unit root tests

To check the stationary of the series, two generations of panel unit root tests have been developed[1]. The first generation of panel unit root tests includes Levin et al. (2002) test, Im et al. (2003) test, Maddala and Wu (1999) test and Hadri (2000) test. The main limitation of these tests is that they assume independence of individual cross sections. However, in practice the series are cross-sectionally dependent. To overcome this difficulty, a second generation of panel unit root tests has been proposed to allow for different forms of cross-sectional dependence. Among these tests, we employ Bai and Ng (2004) test, Moon and Perron (2004) test, Choi (2006) test and Pesaran (2007) test.

3.2 Panel cointegration tests

To test whether the variables are cointegrated, that is, whether there exists a linear combinations of these variables that is stationary, different panel cointegration tests have been appeared[2]. Among these tests, we consider the residual-based tests[3] advanced by Pedroni (2004). The null hypothesis of this test is the absence of cointegration.

It is also possible to adapt Johansen's (1995) multivariate test based on a VAR representation of the variables in the panel data framework. In such context, Groen and Kleibergen (2003) proposed a likelihood-based test[4] to test for a common cointegration rank.

3.3 Panel linear error correction model

Having established that a long-run cointegration relationship exists between non-life insurance premiums, the interest rate and the consumer price index (Equation (2)), we turn to the estimation of this relationship. To this end, we consider the dynamic ordinary least squares (DOLS) estimator introduced by Saikkonen (1991) and Stock and Watson (1993).

As in the time series context, we estimate a panel linear error correction model to reproduce the short-run dynamics of the growth rate of non-life insurance premiums. More

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[1]For a survey of the panel unit root tests, see Banerjee (1999), Baltagi and Kao (2000), Hurlin and Mignon (2005) and Breitung and Pesaran (2008).
[2]For a survey of the panel cointegration tests, see McCoskey and Kao (1998), Baltagi (2000) and Hurlin and Mignon (2005).
[3]The residual-based tests are based on the principle of the Engle and Granger (1987) test in the time series framework and use residuals of the panel static regression to construct the test statistics.
[4]This test is based on the trace test proposed by Johansen (1991, 1995) in the time series framework.

precisely, we estimate the following model[1]:

$$dlpn_{it} = \mu_i + \rho z_{it-1} + \sum_{j=1}^{p} \beta_{1j} dintn_{it-j} + \sum_{j=1}^{p} \beta_{2j} dlipc_{it-j} + \varepsilon_{it}. \quad (3)$$

Where z_{it-1} is the error correction term[2], $dlpn_{it}$ is the logarithm of the nominal non-life insurance premiums considered in first difference (i.e. the growth rate of non-life insurance premiums), $dintn_{it-j}$ are the lagged variations of the interest rate, $dlipc_{it-j}$ is the logarithm of the consumer price index considered in first difference and lagged (i.e. the lagged inflation rate) and ε_{it} is an error term.

Similarly to the time series framework, this specification seems to be restrictive since it assumes that the coefficients β_{1j} and β_{2j} (for $j = 1,..., p$) are constant over the time. In addition, the adjustment to the long run equilibrium is supposed to be symmetric, linear and continuous with a constant adjustment speed measured by the coefficient ρ.

In practice, the coefficients β_{1j} and β_{2j} are not stable over the time due to the presence of structural breaks and the existence of regime change. Moreover, the adjustment to the long run equilibrium appears rather asymmetric, nonlinear and discontinuous[3].

To allow for both heterogeneity of the model (Equation 3) across the countries[4] and time-varying of the estimated parameters $\left(\rho, \beta_{1j} \text{and } \beta_{2j} \text{for} j = 1,..., p\right)$, we propose to model the dynamics of the growth rate of non-life insurance premiums by using the panel smooth transition error correction model.

3.4 Panel smooth transition error correction model

The panel smooth transition error correction model (PSTECM) constitutes an extension of the smooth transition error correction model (STECM) in a panel data framework. The basic idea is that the dynamics of the non-life insurance premiums and the influence of the economic variables vary according two distinct regimes and the transition

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[1] A preliminary regression including the lagged endogenous variables $\left(dlpn_{it-j}\right)$ using the GMM method shows no significant influence of these variables. Consequently, we exclude the lagged endogenous variables from the regression.

[2] z_{it} is given by $z_{it} = lpn_{it} - \hat{\phi}_i - \hat{\theta}_1 intn_{it} - \hat{\theta}_2 lipc_{it}$.

[3] In the same context, Sghaier (2011) has estimated the Equation 3 country by country. She finds evidence of the parameters instability and regime change.

[4] The heterogeneity of the model 3 across the countries is represented by the coefficient μ_i for $i = 1,..., N$.

from one regime to the other is smooth. Following González et al. (2005), the two-regimes PSTECM can be defined as follows:

$$dlpn_{it} = \alpha_i + \left(\rho_1 z_{it-1} + \sum_{j=1}^{p} \beta_{11j} dintn_{it-j} + \sum_{j=1}^{p} \beta_{12j} dlipc_{it-j} \right) + \tag{4}$$
$$g\left(q_{it};\gamma,c\right)\left(\rho_2 z_{it-1} + \sum_{j=1}^{p} \beta_{21j} dintn_{it-j} + \sum_{j=1}^{p} \beta_{22j} dlipc_{it-j} \right) + \varepsilon_{it}.$$

Where α_i denotes the individual fixed effects, ε_{it} is *iid* $\left(0,\sigma^2\right)$, $g\left(q_{it};\gamma,c\right)$ is the transition function that is normalized to be bounded between 0 and 1, γ is the speed of transition from one regime to the other, c is the threshold parameter and q_{it} is the threshold variable which may be the lagged endogenous variables or an exogenous variable.

ρ_1 measures the degree of adjustment in the first regime whereas ρ_2 measures the degree of adjustment in the second regime. β_{11j} and β_{12j} are the coefficients in the first regime whereas β_{21j} and β_{22j} are the coefficients in the second regime.

Following Granger and Teräsvirta (1993), Teräsvirta (1994) and González et al. (2005), we consider the following logistic specification for the transition function:

$$g\left(q_{it};\gamma,c\right) = \left(1+\exp\left(-\gamma\prod_{j=1}^{m}\left(q_{it}-c_j\right)\right)\right)^{-1} \text{ with } \gamma > 0 \text{ and } c_1 \leq ... \leq c_m. \tag{5}$$

Where $c = \left(c_1,...,c_m\right)'$ is an m-dimensional vector of location parameters. In practice, it is usually sufficient to consider $m = 1$ or $m = 2$.[1]

Following the methodology used in the time series context, the PSTECM building procedure consists of three steps: the first one is the specification, the second is the estimation and the third is the evaluation.

Specification

The aim of this step is (i) to test for the linearity (or homogeneity) against the PSTECM specification, (ii) to select the transition variable which corresponds to the variable that minimizes the associated p-value and (iii) to determine the appropriate form of the transition function, that is, to choose the order m of the logistic transition function in Equation (5).

The null hypothesis of linearity test can be expressed as $H_0 : \gamma = 0$ or equivalently, as $H_0' : \rho_2 = \beta_{21j} = \beta_{22j} = 0$. However, under the null hypothesis, the associated tests are

[1] For $m = 1$, the model implies the presence of two extreme regimes whereas for $m = 2$, the model contains three regimes.

nonstandard because the PSTECM contains unidentified nuisance parameters. A possible solution is to replace the transition function $g\left(q_{it};\gamma,c\right)$ by its first-order Taylor expansion around $\gamma = 0$. After reparameterization, this leads to following auxiliary regression:

$$dlpn_{it} = \mu_i + \beta_0^{'*} x_{it} + \beta_1^{'*} x_{it} q_{it} + \ldots + \beta_m^{'*} x_{it} q_{it}^m + \varepsilon_{it}^*. \tag{6}$$

Where $x_{it} = \left(z_{it-1}, dintn_{it-1} \ldots dintn_{it-p}, dlipc_{it-1} \ldots dlipc_{it-p}\right)$, $\beta_1^{'*} \ldots \beta_m^{'*}$ are multiples of γ and $\varepsilon_{it}^* = \varepsilon_{it} + r_m \beta_1^{'*} x_{it}$ (where r_m is the remainder of the Taylor expansion).

Consequently, the null hypothesis of linearity becomes $H_0^{''} : \beta_1^{'*} = \beta_m^{'*}$ in Equation (6). If we denote SSR_0 the panel sum of squared residuals under H_0 (panel linear model with individual effects) and SSR_1 the panel sum of squared residuals under H_1 (PSTECM model with two regimes), the corresponding F-statistic[1] is then given by:

$$LM_F = \frac{\left(SSR_0 - SSR_1\right) / mK}{\left(SSR_0 / \left(TN - N - mK\right)\right)}. \tag{7}$$

Where K is the number of the explanatory variables.

Under the null hypothesis of linearity, the F-statistic has an approximate $F\left(mK, TN - N - mK\right)$ distribution.

Like in the time series context, the selected appropriate transition is the one that minimizes the associated p-value.

Estimation

The estimation of the parameters of the PSTECM consists firstly of eliminating the individual effects μ_i by removing individual-specific means and then in applying nonlinear least squares method to the transformed data.

Evaluation

To validate the PSTECM estimated, we apply the test of no remaining nonlinearity.

In the next section, we focus on the empirical results.

4. EMPIRICAL RESULTS

In this section, we first describe the data. Second, we present the empirical results on the stationary and the cointegration tests. Then, we estimate the panel linear error correction model for the growth rate of non-life insurance premiums and we test the linearity of the

[1] In this paper, we consider the F-version of the test rather than the LM because it has better size properties in small samples.

model. Finally, we estimate a panel nonlinear error correction model for the growth rate of non-life insurance premiums.

4.1 Data

In this paper, we consider annual data for fourteen developed countries[1], namely United States, Canada, Japan, Germany, United Kingdom, France, Italy, Swiss, Belgium, Austria, Denmark, Sweden, Norway and Australia, over the period 1965-2008.

As non-life insurance premiums data, we use nominal direct written premiums obtained from CCA and FFSA for France and from SwissRe for the other countries.

The economic variables include the nominal long-term government bond rate, which is a long-term nominal interest rate for ten years and the consumer price index. These data are extracted from the International Monetary Fund. All the variables are transformed into logarithm form except the interest rate.

Figure 1 illustrates the evolution of non-life insurance premiums compared to the evolution of the interest rate and the consumer price index for each country. We can see that the non-life insurance premiums are related to the economic variables especially after the 1980s.

Figure 2 shows the evolution of the growth rate of non-life insurance premiums compared to the evolution of the variations in interest rate and the inflation rate for each country. We see that the growth rate of non-life insurance premiums exceeds the inflation rate.

4.2 Panel unit root tests

We start by testing the stationarity of the series in levels. For that, we consider the first generation panel unit root tests and the second generation panel unit root tests. The obtained results are reported in Table 1.1 and Table 1.2 respectively. We see that the hypothesis of unit root is accepted for all the variables in levels.

Regarding the stationarity of the series transformed in first difference (see Table 2.1 and Table 2.2 respectively), we notice that all the tests reject the hypothesis of unit root for all the series transformed in first difference.

We therefore conclude that all the variables are integrated of order one (I(1)).

[1] In this paper, we focus on developed countries rather than the emerging countries because the developed countries also present the most developed insurance markets. In particular, the countries selected in this paper share 74% of the global non-life insurance premiums (the non-life insurance premiums of the world).

Table 1.1: First generation tests on the variables in levels

Variables	Model	t^*_ρ	Z_{tbar}	P_{MW}	LM
lpn_{it}	1	-1.320	-1.113	1.200	16.298 ***
	2	-0.669	6.079	3.118	13.168 ***
$intn_{it}$	1	0.107	1.412	1.271	5.030 ***
	2	2.693	0.089	2.463	11.049 ***
$lipc_{it}$	1	1.794	-1.062	46.249	15.605 ***
	2	1.580	2.660	8.959	12.439 ***

Note: (1) and (2) indicate that the model includes individual fixed effects and individual specific time trends respectively. *** indicates a rejection of the unit root hypothesis at the 1% significance level. The lags are selected according to the Ljung-Box and the LM statistics to ensure no serial correlation in the residuals with a maximum lag length of 4. t^*_ρ is the statistic of the Levin et al. (2002) test, Z_{tbar} is the statistic of the Im et al. (2003) test, P_{MW} is the statistic of the Maddala and Wu (1999) test and LM is the statistic of the Hadri (2000) test.

Table 1.2: Second generation tests on the variables in levels

		Bai and Ng test		Moon and Perron test		Choi test		Pesaran test	
Variables	Model	ADF_e	ADF_F	t_a	t_b	P_m	Z	L^*	$CIPS_1$
lpn_{it}	1	3.658	55.374	-1.183	-1.316	1.372	0.430	0.385	-2.123
	2			-1.170	-1.537	3.675	10.084	12.305	-2.581
$intn_{it}$	1	2.753	48.601	-1.107	-1.193	2.714	-0.140	-0.142	1.317
	2			-1.130	-1.086	2.327	1.645	1.573	-2.805
$lipc_{it}$	1	2.058	43.397	1.586	1.911	1.349	-1.201	-1.114	-2.084
	2			-1.002	-0.879	2.896	1.871	1.746	-2.088

Note: ADF_e and ADF_F are the statistics of the Bai and Ng (2004) test, t_a and t_b are the statistics of the Moon and Perron (2004) test, P_m and Z are the statistics of the Choi (2006) test and L^* and $CIPS_1$ are the statistics of the Pesaran (2007) test.

Table 2.1: First generation tests on the variables in first difference

Variables	Model	t^{*}_{ρ}	Z_{tbar}	P_{MW}	LM
$dlpn_{it}$	1	-10.452^{***}	-9.655^{***}	-8.845^{***}	1.200
$dintn_{it}$	1	-17.521^{***}	-15.792^{***}	-13.914^{***}	4.316
$dlipc_{it}$	1	-3.157^{***}	-3.306^{***}	-3.095^{***}	0.993

Note: See Note Table 1.1.

Table 2.2: Second generation tests on the variables in first difference

		Bai and Ng test		Moon and Perron test		Choi test		Pesaran test	
Variables	Model	ADF_{e}	ADF_{F}	t_{a}	t_{b}	P_{m}	Z	L^{*}	$CIPS_{1}$
$dlpn_{it}$	1	1.099	33.638	-52.438	-16.568	1.195	-9.590	-12.498	-3.996
$dintn_{it}$	1	1.135	12.894	-73.153	-19.986	0.720	-13.915	-19.000	-6.133
$dlipc_{it}$	1	1.182	33.980	-20.942	-7.025	1.214	-4.671	-4.879	-3.824

Note: See Note Table 1.2.

4.3 Panel cointegration tests

Now, we check the presence of long-run relationships between non-life insurance premiums and the economic variables. For that, we employ the test of Pedroni (2004) and the test of Groen and Kleibergen (2003). The obtained results are presented in Table 3.1 and Table 3.2 respectively.

Table 3.1: Pedroni test

Panel	Panel	Panel	Panel	Panel	Panel	Panel
v-stat	rho-stat	PP-stat	ADF-stat	rho-stat	PP-stat	ADF-stat
1.982	-0.605	-1.348	-1.892^{*}	0.733	-1.064	-3.033^{***}

Note: *** and * indicate a rejection of the null hypothesis of no cointegration at the 1% and 10% significance level respectively.

Table 3.2: Groen and Kleibergen test

$LR(0\backslash 1)$	102.200^{***}
	$[0.000]$
$LR(1\backslash 2)$	36.320
	$[0.136]$
$LR(2\backslash 3)$	34.540
	$[0.184]$

Note: LR is the statistic of the Groen and Kleibergen (2003) test. The numbers in brackets are the p-values. *** indicates a rejection of the null hypothesis of no cointegration against one cointegration relationship at the 1% significance level.

According to the Pedroni test, we conclude that the null hypothesis of no cointegration is rejected at the 1% significance level. Moreover, the Groen and Kleibergen test indicates that the rank of cointegration is equal to one. Consequently, we conclude to the presence of a long-run relationship between the variables.

4.4 Linear modelling of the growth rate of non-life insurance premiums

The estimated results of the long-run relationship between non-life insurance premiums, the interest rate and the consumer price index (Equation (2)) using DOLS is given by:

$$lpn_{it} = \phi_i - \underset{(-17.810)}{5.620^{***}}\, intn_{it} + \underset{(164.186)}{1.723^{***}}\, lipc_{it} + z_{it}. \tag{8}$$

Where the numbers in parentheses below the parameter estimates are the t-Ratios. *** denotes statistical significance at the 1% significance level.

We see that the coefficient of the interest rate and the consumer price index have the expected signs, respectively negative and positive. These results are consistent with the financial insurance pricing model and lead us to support the rational expectation/institutional intervention hypothesis to explain the fluctuations of non-life insurance premiums. These results are similar to those of Haley (1993, 1995, 2007), Grace and Hotchkiss (1995) and Blondeau (2001) who found that measures of underwriting profits are negatively cointegrated with the interest rate and positively cointegrated with the consumer price index.

The short-run dynamics of the growth rate of non-life insurance premiums is described by the panel linear error correction model (Equation (3)) estimated by DOLS and is given by[1]:

$$dlpn_{it} = \mu_i - \underset{(-4.585)}{0.079^{***}}\, z_{it-1} + \underset{(2.079)}{0.693^{**}}\, dintn_{it-1} + \underset{(8.170)}{0.945^{***}}\, dlipc_{it-1} + \varepsilon_{it}. \tag{9}$$

Where the numbers in parentheses below the parameter estimates are the t-Ratios. *** and ** denotes statistical significance at the 1% and 5% significance level respectively.

[1]We note that we obtain similar result if we consider others estimators like the ordinary least squares estimator or the fully modified ordinary least squares estimator.

We see that the coefficient of the first lag of the error correction term is significant and negative meaning an error correction mechanism. This case corresponds to the situation where the level of the non-life insurance premiums lpn_{it-1} at date $t-1$ is too high compared with its equilibrium level $\left(\text{given by} - 5.620intn_{it-1} + 1.723lipc_{it-1}\right)$, the term $\left(-0.079z_{it-1}\right)$ is strictly negative and exerts a downward influence on the variation of non-life insurance premiums $dlpn_{it-1}$ such that the long-run relationship can be verified at date t.

We see a dual effect of the interest rate on the non-life insurance premiums: a negative persistent effect transmitted by the long-run relationship and characterized by a coefficient equal to $\left(-0.079 \times 5.620 = -0.443\right)$ as well as positive transitory effect with a coefficient equal to 0.693. This yields a total effect measured by the coefficient $\left(-0.443 + 0.693 = 0.250\right)$ which is positive and implies that an increase in the variations of the interest rate leads to higher premiums. This result is similar to those of Choi et al. (2002), who found a negative relationship between the economic loss ratio and the interest rate. One possible explanation lies in the fact that high interest rates are a sign of strong economic growth, and therefore a higher demand for the insurance, thus implying an increase in the collection of non-life insurance premiums.

We observe a dual effect of the consumer price index on non-life insurance premiums: a positive persistent effect transmitted by the long-run relationship and characterized by a coefficient equal to $\left(0.079 \times 1.723 = 0.136\right)$ as well as positive transitory effect with a coefficient equal to 0.945. This yields a total effect measured by the coefficient $\left(0.136 + 0.945 = 1.081\right)$ which is greater than 1 and therefore indicates an overreaction on the part of non-life insurance premiums to the inflation. This result is similar to those of Eling and Luhnen (2008) who found a positive relationship between the growth rate of non-life insurance premiums and the inflation rate.

As we have annouced previously, the panel linear error correction model seems inappropriate to describe the dynamics of the growth rate of non-life insurance premiums since the estimated parameters vary over the time.

4.5 Nonlinear modelling of the growth rate of non-life insurance premiums

In this section, we propose to use the panel nonlinear error correction model to model to dynamic of the growth rate of non-life insurance premiums. We begin by testing the linear specification of the panel error correction model against a PSTECM specification using the linearity tests described above. If the null hypothesis of linearity is rejected, it will be necessary, in a second step, to determine the number of transition functions.

The results of the linearity tests and the specification test of no remaining nonlinearity, using different candidate transition variables[1], are summarized in Table 4.

Table 4: Homogeneity tests

	$H_0: m=0$ against $m=1$	$H_0: m=1$ against $m=2$
z_{it-1}	3.233^{**}	2.839
	$[0.042]$	$[0.370]$
z_{it-2}	0.386	0.798
	$[0.680]$	$[0.671]$
$dintn_{it-1}$	0.240	0.000
	$[0.869]$	$[1.000]$
$dintn_{it-2}$	1.443	0.142
	$[0.229]$	$[0.935]$
$dlipc_{it-1}$	2.990^{**}	1.184
	$[0.031]$	$[1.184]$
$dlipc_{it-2}$	6.585^{***}	0.245
	$[0.011]$	$[0.621]$

Note: The statistic of the test is given by Equation (7). The numbers in brackets below the parameter estimates are the p-values. *** and ** indicate a rejection of the null hypothesis of homogeneity test at the 1% and the 5% significance level respectively.

The null hypothesis of linearity is rejected at the 1% significance level. The lower value of the p-value of the LM_F test is obtained for the second lag inflation rate. So, we retain this variable as a transition variable.

In addition, the specification test of no remaining nonlinearity leads to specification with one transition function. We therefore proceed to the estimation of the PSTECM with two extreme regimes (Equation (4)). The obtained results are presented in Table 5.

[1]As possible transition variables, we choose the lagged error correction term $\left(z_{it-1} \text{and} z_{it-2}\right)$, the lagged variations in interest rate $\left(dintn_{it-1} \text{and} dintn_{it-2}\right)$ and the lagged inflation rate $\left(dlipc_{it-1} \text{and} dlipc_{it-2}\right)$.

Table 5: Estimation results of the PSTECM

		Regression 1	Regression 2
Regime 1	z_{it-1}	-0.082 ***	-0.181 ***
		(-3.281)	(-4.200)
	$dintn_{it-1}$	1.419	
		(1.514)	
	$dlipc_{it-1}$	-0.134	
		(-0.588)	
Regime 2	z_{it-1}	0.068 ***	0.043 ***
		(2.120)	(3.602)
	$dintn_{it-1}$	-0.775	
		(-1.204)	
	$dlipc_{it-1}$	0.651	
		(1.137)	
	γ	171.109	123.792
	c	0.034	0.027

Note: Regression 2 excludes the variables that are not significant in Regression 1. *** denotes statistical significance at the 1% significance level. γ and c are respectively the speed of transition and the threshold parameter defined by Equation (5).

We find evidence of two extreme regimes. In the first regime, when the transition variable q_{it} (represented here by the second lag inflation rate $dlipc_{it-2}$) is below the estimated threshold parameter $(c = 27\%)$, which correspond to the most recent period, the coefficient of the first lag error correction term (z_{it-1}) is significant and negative implying the existence of an error correction mechanism.

The coefficients of the first lag of the variations of the interest rate and the inflation rate are not significant meaning that there is no short-run influence (transitory effect) of the economic variables on the growth rate of non-life insurance premiums. However, there is a negative long-run influence (persistent effect) of the interest rate $(-0.181 \times 5.620 = -1.018)$ on the growth rate of non-life insurance premiums (passing through error correction mechanism). This may be explained by the fact that the insurers did not take into account investment income and more generally the economic conditions in the ratemaking process until the 1980s. The inflation rate has a positive long-run influence on the growth rate of non-life insurance premiums $(0.181 \times 1.723 = 0.312)$

The second regime occurs when the inflation rate exceeds 27% which corresponds to the earliest period. The coefficient of the first lag error correction term is significant but positive implying that there is not a mean reversion. The first lag of the variations of the interest rate and the inflation rate are not significant meaning no short-run influence of the economic variables on the growth rate of non-life insurance premiums. However, we find a positive long run influence of the interest rate $(0.043 \times 1.723 = 0.074)$. In addition, we find a negative long-run influence of the inflation rate $(-0.043 \times 5.620 = -0.241)$. This result is similar to D'Arcy (1982) who found that the inflation rate affected negatively the non-life insurance industry during the inflationary periods. Indeed, a higher than expected inflation rate will cause the profitability and therefore the premiums to decrease whereas a lower than expected inflation rate will increase the profitability and the premiums.

These empirical findings lead us to conclude that the non-life insurance pricing rules have changed in all countries and that this change is linked to the inflation rate and more generally to the economic conditions. This result is similar to the one obtained by Higgings and Thistle (2000), Leng et al. (2002), Leng and Meier (2006), Jawadi et al. (2009) and Sghaier and Bruneau (2009a) who found strong evidence of regime change in the relationship between non-life insurance premiums (or measure of underwriting profits) and the interest rate. In addition, Krivo (2009) and Sghaier and Bruneau (2009b), found strong evidence of regime change between the non-life insurance premiums (or measure of underwriting profits) and the inflation rate.

The estimated transition function at the observed second lag inflation rate is plotted in Figure 3. We observe that the transition function increases smoothly throughout the range of the data, rather than jumping from one regime to the other. Indeed, most of the observed values of the transition function are close to either 0 or 1 suggesting one regime or the other holds in most of the periods.

5. CONCLUSION

The main objective of this paper is to examine the empirical influence of the consumer price index and the interest rate on the volume of non-life insurance premiums in fourteen countries over the period 1965-2008. For that, we use recent developments of nonlinear models in a panel data framework. The panel unit root tests show that the series are integrated thus we adopt an econometric approach based on nonlinear cointegration. The panel cointegration tests results show that the series are cointegrated. We then estimate the long-run relationship and we deduce the linear error correction model for the growth rate of non-life insurance premiums. However, this specification seems inappropriate since the linearity tests provide evidence of a nonlinear relationship. We therefore estimate a smooth transition error correction model for the growth rate of non-life insurance premiums. The empirical results show that the economic conditions affect the insurance industry differently depending on the value of the (second lag) inflation rate. During the inflationary periods, the effects of the interest rate and the inflation rate on the non-life insurance premiums are confirmed positive and negative respectively. However, in deflationary periods, the non-life insurance premiums are negatively related to the interest rate and positively related to the inflation rate.

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FIGURES

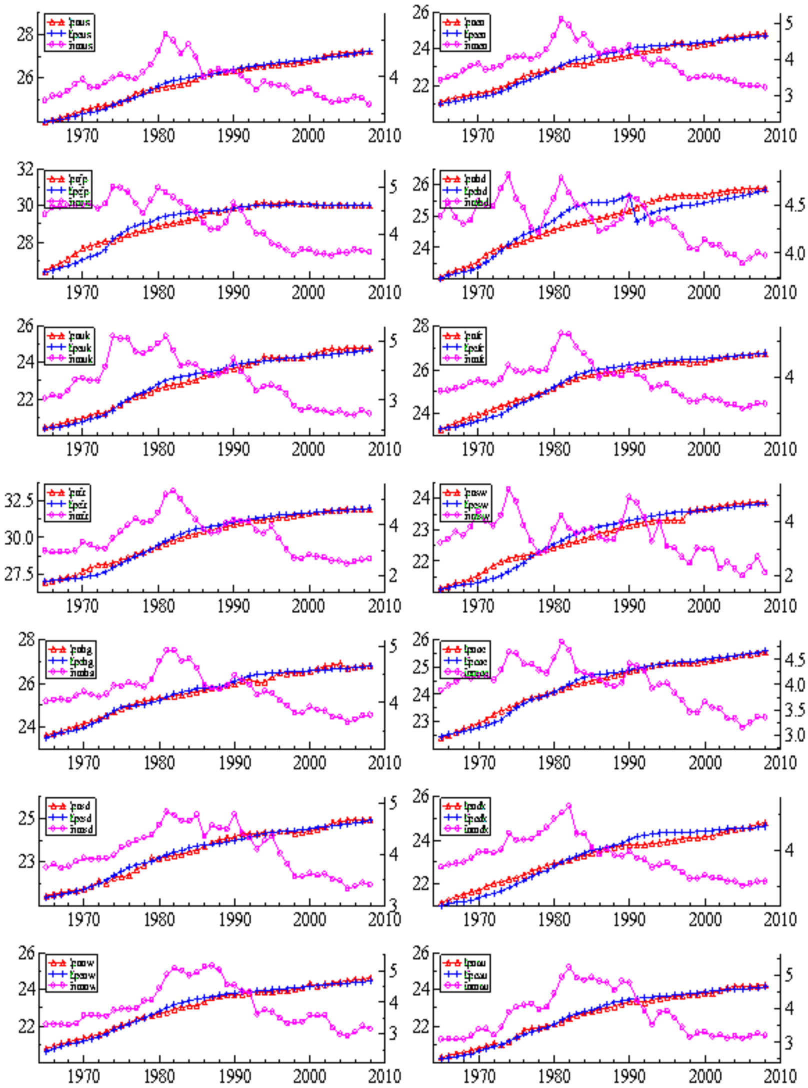

Figure 1 : Non-life insurance premiums and economic variables in levels

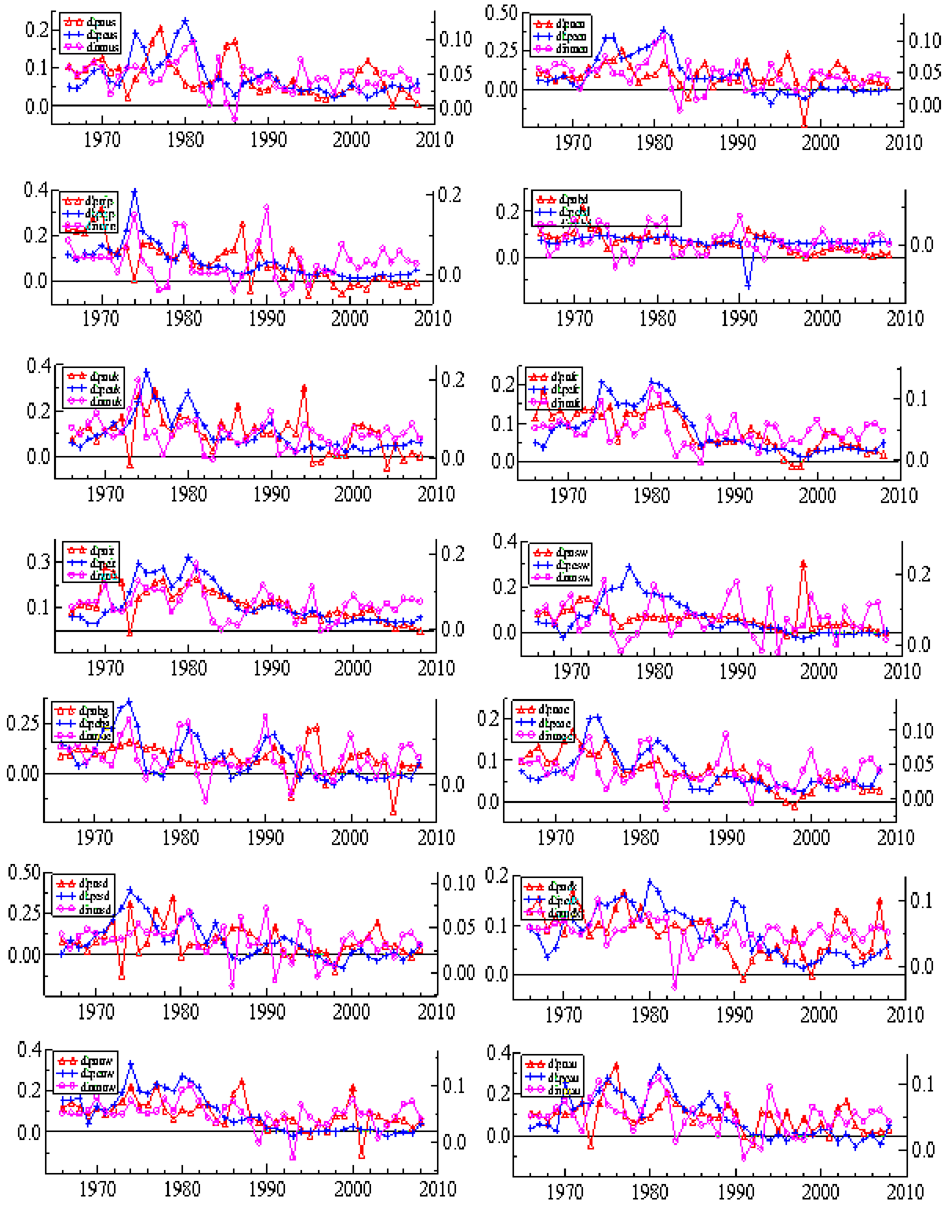

Figure 2 : Non-life insurance premiums and economic variables in first difference

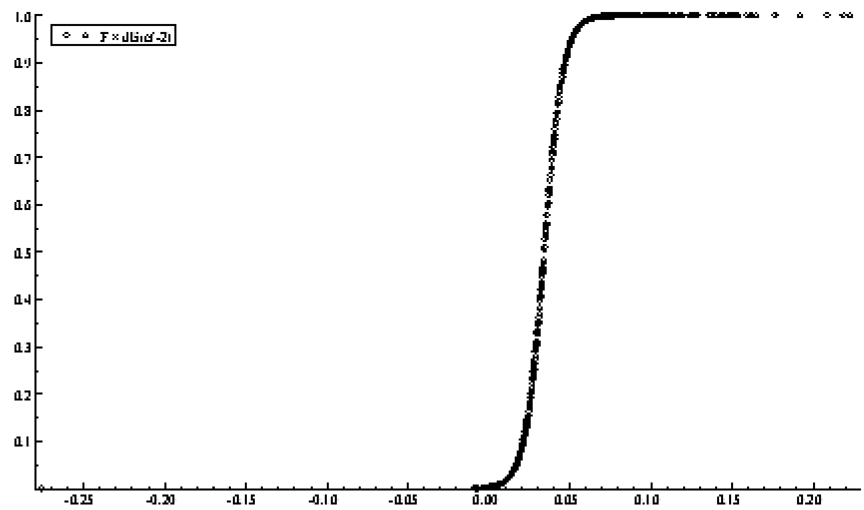

Figure 3 : Estimated transition function