Capital Structure and Product Market Competition: Evidence from the EU Life Insurance
Industry

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Abstract

It is a conventional wisdom that solvency regulation decreases product market competition. The thesis argues that this view could be erroneous. The existing literature overlooks a fundamental risk-incentive mechanism associated with imperfect product markets. This thesis develops a theory that embeds the product market frictions' mechanism and the traditional costs of equity financing mechanism to explain product market decisions. The theory predicts that insurance premium is a "U" shaped function of the solvency ratio. The study of the natural experiment in the United Kingdom (UK) life insurance industry in 2005 supports the theory.

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Chapter 1

Introduction

Recently, there has been a lot of attention in the media focused on the Solvency II Directive 2009/138/EC. Primarily this European Union (EU) legislation concerns the amount of capital that EU insurance companies must hold to reduce the risk of insolvency. Once the Solvency II directive is approved by the European Parliament, it will be scheduled to come into effect on January 1, 2013. The Solvency II regulation aims to enhance consumer protection, because the current EU capital minima for insurance companies, as generally accepted, are insufficient. The conventional wisdom is that the enhanced protection of customers comes at a price: according to a survey by London-based Interim Partners Ltd, 88% of senior interim financial services executives believe that the Solvency II regulation ultimately would result in higher costs for insurance buyers.

This thesis argues that the generally accepted idea of the trade-off between safety and low insurance premiums may not work in the presence of product market frictions: "tightening up" of solvency regulation may actually both decrease insurance premiums and improve safety. The role of product market frictions for pricing behavior was first demonstrated for supermarket industry by Chevalier and Scharfstein (1995) (C-S). They define product market frictions as "switching costs": if the customer has chosen a particular firm today, it is costly for her to switch to another firm in the future. C-S show that the firm's motivation to compete depends on the expected future benefits from new customers. Firms with higher leverage ratios are riskier and are unable to take full advantage of the locked-in customers; consequently they are less motivated to compete. In this thesis the idea of C-S model is applied to insurance companies. However this is the first time in the literature that C-S model is used to describe financial intermediaries, so it has to be extended over a number of dimensions.

The theory suggested in this thesis embeds two incentive mechanisms counteracting each other: (A) C-S inspired market friction effect, and (B) traditional agency costs associated with equity financing. Building up on the C-S idea, I consider two competing insurance companies on the product market with frictions (switching costs). "Tight" solvency regulation decreases capital leverage ratio[1] of the insurance company as well as decreases insurance company's risk exposure. Consequently, "tight" solvency regulation, by means of market friction mechanism (A), motivates insurance companies to compete. On the other hand, "tight" solvency regulation, by means of agency costs mechanism (B), discourages competition. When I consider two mechanisms (A) and (B) simultaneously, the theory predicts that the equilibrium premium as a function of solvency ratio[2] has a "U" shape[3]. Let us denote the solvency ratio that results in the lowest insurance premium as the "optimal" solvency ratio (or optimal solvency regulation).

We can formulate the model's predictions as four testable *Hypotheses*. If the regulator increases solvency ratio, but it is still below the optimal level, the following results should hold:

- *Hypothesis 1*: The premium will decrease.

- *Hypothesis 2*: The number of outstanding contracts will increase.

  The "tightening up" of solvency regulation primarily affects insurance companies with low capital. Consequently:

- *Hypothesis 3*: Low capital companies will decrease their premiums more than high capital companies.

- *Hypothesis 4*: Low capital companies will increase their clientele more than high capital companies.

Changing the focus of the C-S study to insurance companies is not only interesting by itself, but it also has the important practical consequence: we can now find a natural experiment where a regulator exogenously changes solvency ratio. This thesis studies the effect of the Risk Based Capital Adequacy regulation (RBC) adopted by the UK financial authority since 2005. The data for empirical tests are from the Van Dijk ISIS Database. The sample

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[1]Here I rely on a simple definition of insurer's leverage ratio as the ratio of equity capital to total assets or solvency ratio in insurance terminology.

[2]Solvency ratio = Capital/Assets

[3]If product market frictions large enough.

includes financial reports of approximately 500 EU life insurance companies. The total number of records are 3000, and years are from 1997 to 2007.

The RBC regulation was aimed to increase solvency ratios in response to the wave of bankruptcies in UK life insurance industry in 2001-2002. The average solvency ratio before RBC adoption in 2005 was 9.4%, and after RBC adoption it increased up to 11.5%. To check if *Hypotheses* 1-4 are applicable, I calculated the optimal solvency ratio based on conservative estimates of the agency costs, product market frictions, and volatility of profit. The calculated optimal ratio was 14.9%. Consequently *Hypotheses* 1-4 are applicable to this case: the increase of the capital from pre 2004 9.4% to post 2004 11.5% was a step in the right direction towards the optimal 14.9%. We expect to see an increase in competition, decrease of premiums, and increase of the number of contracts sold in the industry. On the contrary according to the traditional view, the more restrictive RBC regulation should lead to a decrease of competition, to higher premiums, and to a lower number of sold contracts in the industry.

I test *Hypotheses* 1-2 with the help of fixed effect regressions, where a dummy variable indicates the "treated" subsample. The dummy equals one for UK companies after 2004 and zero otherwise. The estimated coefficients of the dummy are statistically significant, and are equivalent, on average, the $26\% \pm 11\%$ decrease of premiums and the $11\% \pm 6\%$ increase of total number of contracts after the 2005 adoption of the RBC. To test *Hypotheses* 3-4, the fixed effect regression was extended by adding the interaction term Dummy*(Capital/Assets or Funds/Assets). The regression results in general indicate that the insurance companies with low capital level are the ones who responded more actively to the new RBC regulation. These empirical results support the theory advocated in this thesis.

Thus, my research contributes to two trends of literature: the first one studies the effect of capital structure on product market strategies of non-financial firms, while the second one investigates the effect of solvency regulation on the product market competition. Contrary to financial companies, the effect of capital structure on product market strategy decisions of non-financial firms has been studied relatively well: there are both theoretical and empirical studies (e.g. Chevalier and Scharfstein (1995); Kovenock, Phyllips (1997); Zingales (1998); Khanna, Tice(2000); Campello (2010); among others).

The second trend of the literature comprises works which study how the solvency regulation of insurance companies affects competition and efficiency. Rees and Kessner (1999) provide some empirical evidence that tighter solvency regulation allows the survival of high cost firms, and, as a result, worsens the welfare of insurance buyers. Some other papers, such as Chiesa (2002); Frame, White, (2007), use the formula "liberalized solvency reg-

ulation equals to improved competition" as an axiom in their analysis. This view is not only common in the literature but it was a rationale for a number of waves of deregulation. Often a deregulation was followed by a tightening of regulation, as the regulators struggle to find the optimal social balance between efficiency and safety. This thesis suggests that sometimes we do not have to choose from two evils.

The rest of the thesis proceeds as follows: Section 2 describes the model, Section 3 formulates hypotheses, Section 4 discusses data sample and natural experiment, Section 5 explains methodology of tests and empirical results, and Section 6 concludes.

1.1 Literatrue review

Solvency regulation seeks to mitigate the risk of policyholders by determining how much capital an insurer should hold. By doing so solvency regulation puts a limit on financial leverage of the insurer. However solvency regulation not only affects the choice of capital structure but also influences product market behavior of insurance companies. The interaction between capital structure and product market behavior is two-directional and exists through many channels. Further I organize my literature review in two groups: the first is about the effect of capital structure on product market behavior and the second studies the effect of product market strategies on the choice of capital structure.

1.2 Effect of capital structure on product market strategies

There are two views about the effect of capital structure on product market competition. The first view goes back to Hubbard (1996), who documents that capital market imperfections are likely to play a role in all type of investment decisions. Hendel (1996) presents a theoretical model where financially constrained firms tend to reduce prices in bad times in order to raise cash at the expense of inventories. Bottasso, Galeotti, and Sembenelli (1997) focus their attention specifically on the impact of financial constraints on a particular type of investment decisions that forward looking firms typically make investment in market shares by appropriately pricing their products. Botasso et al. look at both the theoretical and empirical behavior of price-cost margins when capital market imperfections affect firms markup policies. They present a model of a firm facing imperfect markets for financing operations, and estimate it using data for several hundred Italian firms over the period 1981-1993. Their empirical findings suggest that due to capital market imperfections firms pay a premium on external finance which significantly depends on the debt to sales ratio.

Also according to their estimates constrained firms find it optimal to cut price compared to unconstrained firms. As firms are more likely to be financially constrained in recessions, their results imply that financial market imperfections tend to make markups pro-cyclical.

Busse (2000) studies the effect of financial condition on the decision to start a price war in the airline industry. Using data on 14 major airlines between 1985 and 1992, she tests the hypothesis that firms in worse financial condition are more likely to start price wars. Empirical results suggest that this is true, particularly for highly leveraged firms. Almeida, Campello, and Weisbach (2011) demonstrate that future expected financial constrains affect firms investing decisions as well. Firms with dim financial future choose investments with shorter payoff time, with less risk, and that utilize more pledgeable assets.

Fresard (2010) shows that large cash reserves lead to systematic future market share gains at the expense of industry rivals. Moreover, his analysis reveals that the competitive effect of cash is markedly distinct from the strategic effect of debt on product market outcomes. This effect is stronger when rivals face tighter financing constraints and when the number of interactions between competitors is large.

The second view on the capital structure effect was suggested by Greenwald et al. (1984), and then developed by Gottfries (1991), Klemperer (1993), and Chevalier and Scharfstein (1995). This view is based on the idea of imperfect competition. On imperfect product markets customers are to some extent locked up with the firm. When the firm chooses a price for its product it essentially makes an investment in the growth of market share. If the firm choses a low price, the firm attracts new customers. Offering low price the firm loses money today. These losses can be considered as an investment. And new customers will bring extra profit in the future. That extra profit can be considered as a payoff on the investment. If the firm finances its operations with the help of debt, the firm is riskier and the future payoff from new customers is less certain. Such firm should be less motivated to invest in growth of market share and should charge a higher price for its product. If this logic is true, it can explain counter-cyclical nature of mark-ups. In good times firms expect better business conditions in the future, so they compete more aggressively for the future share on the market. It means that during boom mark-ups decrease, and in recessions mark-ups increase. Chevalier and Scharfstein predictions find mixed support in the empirical studies.

Dueker, Thornton (1997) propose a switching cost model, and find supportive empirical evidence for the hypothesis that bank loan mark-up is counter-cyclical and asymmetric in its responsiveness to recessionary and expansionary impulses.

Campello (2003) demonstrate some empirical evidence for counter-cyclical nature of mark-ups. He provides firm- and industry-level evidence of the effects of capital structure

on product market outcomes for a large cross-section of industries over a number of years. The analysis uses shocks to aggregate demand as surrogates for exogenous changes in the product market environment. Campello finds that debt financing has a negative impact on firm (relative-to industry) sales growth in industries in which rivals are relatively unlevered during recessions, but not during booms. In contrast, no such effects are observed for firms competing in high debt industries. At the industry level, markups are more countercyclical when industry debt is high.

However Campello (2005) proposes that debt can both boost and hurt firms product market performance. He first models a non-monotonic relation between debt-like finance and competitive conduct. And then he empirically examines the within-industry relation between leverage and sales performance using data from 115 industries over 30 years. Campello finds that moderate debt taking is associated with relative-to-rival sales gains; high indebtedness, however, leads to product market underperformance.

1.3 Effect of product market strategies on capital structure choices

The effect of product market strategies on capital structure is often indirect. The product market strategy is tightly related to structure of assets. Campello (2012) demonstrates that there is a relation between asset structure and capital structure of an industrial firm. To do so he exploits variation in the salability of corporate assets. Theory suggests that asset tangibility increases borrowing capacity because it allows creditors to more easily repossess a firm's assets. Tangible assets, however, are often illiquid. Campello shows that the redeployability of tangible assets is a main determinant of corporate leverage - beyond standard proxies for tangibility. To establish this link, he distinguish across different asset categories in firms' balance sheets (e.g., machinery, land and buildings) and use an instrumental approach that incorporates measures of supply and demand for those individual assets. He also uses a natural experiment driving differential increases in the supply of real estate assets in some regions of the country: The Defense Base Closure and Realignment Act of 1990. Consistent with a credit supply-side view of capital structure, he finds that asset redeployability is a particularly important driver of leverage for firms that are likely to face credit frictions (e.g., small, unrated firms). Compellos tests also show that asset redeployability facilitates borrowing the most during periods of tight credit in the economy. Istaitieh, Rodrguez examine the interactions between capital structure and factor-product markets

through a system of simultaneous equations with panel data. Their data set contains a sample of Spanish manufacturing firms between 1993 and 1999. They specify a financial leverage equation that depends mainly on factor-product markets and show empirically that capital structure empirically affects and is affected by factor-product markets.

Chapter 2

The Model of an Insurance Company

In this chapter I present a model of simple insurance industry to study the effect of capital structure on product market decisions. The model I suggest is inspired by Chevalier-Scharfstein, 1994, (C-S) who investigate the dynamics of product market competition when consumers face switching costs and firms operate on product markets with imperfections. My approach is different from C-S's in a number of aspects. First, I adopt the model to the case of financial intermediaries by including the capital adequacy (solvency) regulation. Changing the focus of my research from industrial firms to financial intermediaries is not only interesting by itself, but also opens a regulatory prospective on the problem. Second, I introduce costs associated with equity capital. And third, I consider a population of overlapping generations of agents, rather than a two time period setup. Similar to C-S, I consider a case of duopoly market.

2.1 Regulator

The regulator manages its guaranty fund which pays the claims to policyholders in the case of insurer's bankruptcy. Consequently, the demand for insurance policies does not depend on risk exposure of the insurance company. The guarantee fund is financed by insurance companies. I assume that insurance companies pay a fair contribution to the guarantee fund. In other words, risk-shifting value of the insurance company equals to the contribution to the guarantee fund. The regulator also determines the solvency ratio s defining the minimal level of capital per one client. It is costly for the insurer to have more

capital then the minimal level and there are no benefits in the model associated with extra capital, so insurers always would choose to have the minimal capital level.

2.2 Policyholders

Policyholders live two periods and insure risks each period of their life. Each time t, young policyholders form one half of the population, and old policyholders are the other half. The total population does not change with time.

The expected insurance claims per policyholder are 1 for every period of their life. The total claims to the insurance company is a stochastic variable, and the risk of claims is systematic and non-diversifiable. The distribution of claims per one client is Gaussian $N(1, \sigma)$ (I use Gaussian distribution for simplicity, the results of the theory hold for any U shape distribution.).

Further I denote two insurance companies as company A and company B. Policyholders choose between insurer A and insurer B in the first period of their life and then stay with the same insurer for the second period. There are product market inefficiencies: after we attract a new customer offering her a low initial premium $1 + \pi_t$, we can increase next period premium to some extent. The customer is ready to pay more during the second period of her life, because it is costly for her to switch to a new provider. I define the second period premium as $1 + \pi_{second, t+1} = 1 + \pi_t + \delta$, where δ is a constant parameter describing market inefficiencies. Demand function for the company A is a linear function of premium offered by the company A and of premium company B:

$$N_{A,t} = N_0 - \alpha \pi_{A,t} + \beta \pi_{B,t}, \qquad (2.1)$$

where N_{At} is a number of clients who purchased insurance contracts from company A for the first time. The demand function for the company B is identical.

2.3 Insurance companies

For simplicity I assume that investors are risk neutral, and risk free return is zero. On imperfect markets, policyholders may pay premium for the policy contract higher than its "fair" price, which is an expectation of future claims in my "risk neutral" model. The insurance company creates value for shareholders through two mechanisms: when it sells contracts for a price higher than fair value, and when it shifts risks to policyholders. By

assumption, the risk shifting value of the insurance company equals to the payments to the guarantee fund, and that leaves us only one source of value - the difference between the market premium and the fair premium $\pi_{i,t} + 1 - 1 = \pi_{i,t}$ (which is intuitively close to mark-up concept in C-S). Then, the value of the company can be formalized as:

$$V_{A,t} = N_{A,t-1}(\pi_{A,t,second} - se) + N_{A,t}(\pi_{A,t} - se) +$$
$$+p(s) * (N_{A,t}(\pi_{A,t+1,second} - se) + N_{A,t+1}(\pi_{A,t+1} - se)) + ..., \tag{2.2}$$

where s - solvency ratio defining the minimal capital of the insurer per one client, se - the agency costs proportional to the capital s, $1 + \pi_{A,t}$ and $1 + \pi_{B,t}$ - premiums of the company A and company B per client for new clients, $1 + \pi_{A,t,second}$ and $1 + \pi_{B,t,second}$ - premiums of the company A and company B per client for new clients, $N_{A,t}(\pi_{A,t})$ - number of contracts sold by company A, $p(s)$ - probability of bankruptcy (the bankruptcy defined as an event when claims per client exceed $1+s$), δ - product market frictions, $N_{A,t} = N_0 - \alpha\pi_{A,t} + \beta\pi_{B,t}$ - demand function, N_0, $\alpha > 0$ and $\beta > 0$ - constant parameters of the demand functions.

After plugging in the formula for the second period premium into (), we obtain:

$$V_At = N_{A,t-1}(\pi_{A,t-1} + \delta - se) + N_{A,t}(\pi_{A,t} - se) +$$
$$+p(s) * (N_{A,t}(\pi_{A,t} + \delta - se) + N_{A,t+1}(\pi_{A,t+1} - se)) + ... \tag{2.3}$$

The insurance company chooses its premium π_{At} to maximizes its value $V_{At}(\pi_{At})$. We can find the equilibrium premium $1 + \pi^*$ analyzing first and second order conditions:

$$FOC : N_0 - 2\alpha\pi_{A,t} + \beta\pi_{B,t} + \alpha se + \alpha\delta\frac{p(s)}{1 + p(s)} = 0, \tag{2.4}$$

$$SOC : -2\alpha < 0. \tag{2.5}$$

So we always have a local maximum, and the optimal premium is:

$$1 + \pi^* = 1 + \frac{1}{2\alpha}(\beta\pi_{B,t} + N_0 + \alpha se + \alpha\delta\frac{p(s)}{1 + p(s)}). \tag{2.6}$$

We can notice that in equilibrium the premium does not depend on time, and the same for companies A and B. That allows us to solve () for π^*:

$$\pi_* = \frac{N_0 + \alpha(se - \delta p(s))}{2\alpha - \beta},$$

(2.7)

where I use an approximate formula $\frac{p(s)}{1+p(s)} = p(s)$ that works for $p(s) << 1$.

2.4 Analysis

Lets first consider the case when product market is perfect, and parameter δ is 0. Then, in agreement with the traditional view, the equilibrium premium is an increasing function of solvency ratio s:

$$1 + \pi^* = 1 + \frac{N_0 + \alpha se}{2\alpha - \beta},$$

(2.8)

where e - capital costs, and N_0, $\alpha > 0$, and $\beta > 0$ - parameters of the demand function.

In the case of the market with imperfections, the derivative of the equilibrium premium is:

$$\frac{\partial(1 + \pi_*)}{\partial s} = \frac{\alpha}{2\alpha - \beta}(e - \delta \frac{1}{\sqrt{2\pi}\sigma} \exp(-\frac{s^2}{2\sigma^2})),$$

(2.9)

where σ is the volatility of aggregated claims. If $e >= \delta \frac{1}{\sqrt{2\pi}\sigma}$, then as in the previous case equilibrium premium is a decreasing function of solvency ratio. However if $e < \delta \frac{1}{\sqrt{2\pi}\sigma}$, the equilibrium premium first decreases with solvency ratio while solvency ratio is less then the optimal ratio $s < s^*$, and then the equilibrium premium increases with increase of solvency ratio (when $s > s^*$). The optimal solvency ratio minimizes the equilibrium premium $1 + \pi^*$, and it has the following expression:

$$s^* = \sqrt{-2\sigma^2 \ln(\frac{e\sigma\sqrt{2\pi}}{\delta})},$$

(2.10)

The optimal solvency ratio s^* increases with market imperfections δ, and decreases with capital costs e.

2.5 Extension: Selective regulatory effect

In my model insurance companies optimally choose to have a minimal level of capital. In real life companies often have more than the required amount of capital. When insurer tightens up solvency regulation the companies with low level of capital will be the ones who affected by the change in the regulation on the first place. To study this case I offer an extension of my model where firms have different solvency ratios: company A has solvency ratio s_A, and company B - s_B. Following the above solution for the identical companies A and B, we can find the equilibrium premium for the case A $\neq$ B:

$$\pi_A^* = \frac{1}{1 - \frac{\beta^2}{4\alpha^2}}((1 + \frac{\beta}{2\alpha})N_0 + \alpha(s_A e + \delta p(s_A)) +$$

$$+ \frac{\beta}{2}(s_B e + \delta p(s_B))), \tag{2.11}$$

the formula for π_B^* is symmetrical. It is easy to show that

$$\frac{\pi_A^*}{s_B} = \frac{\beta}{2\alpha}\frac{\pi_A^*}{s_B}. \tag{2.12}$$

We know that $\frac{\beta}{2\alpha} < 1$, or in other words: if change of regulation affects only company B, the resulting change in premium of company B is higher than the change in premium of company A.

2.6 Hypotheses

My model was designed to combine two factors affecting the competitive outcome in the product market of the insurance industry: agency costs associated with equity financed capital, and the negative effect of the bankruptcy risk on the insurer's motivation to compete on imperfect product markets. The theory produces a set of predictions different from the traditional view in the literature, if the following conditions hold:

$$I) e < \delta \frac{1}{\sqrt{2\pi}\sigma}, \tag{2.13}$$

insurance industries are characterized by high product market imperfections, and low costs of capital.

$$II) s_1 < s*, \tag{2.14}$$

solvency ratio before the change in regulation s_1 is lower then the optimal solvency ratio s^*.

$$III)s_2 < s*, \tag{2.15}$$

solvency ratio after the change in regulation s_2 is lower then the optimal s^* .

Now I will summarize the predictions of the theory as four hypotheses:

Hypothesis 1:   If conditions I) - III) hold, the regulatory increase of solvency ratio leads to decrease of premiums.

Hypothesis 2:   If conditions I) - III) hold, the regulatory increase of solvency ratio leads to increase of the number of contracts sold.

Hypothesis 3:   If conditions I) - III) hold, the insurance companies with low capital levels will decrease their premiums in response to the regulatory increase of solvency ratio relatively more than the companies with high level of capital.

Hypothesis 4:   If conditions I) - III) hold, the insurance companies with low capital levels will increase number of sold contracts in response to the regulatory increase of solvency ratio relatively more than the companies with high level of capital.

Chapter 3

Empirical Findings

In this chapter I test the theoretical predictions derived in the previous chapter.

3.1 Data and Opportunity for Natural Experiment

I use Van Dijk ISIS Database of financial reports of around 250 German, 130 Austrian, 100 France, and 150 United Kingdom life insurance companies for years from 1997 to 2007. The sample contains only corporations, the mutual insurance companies are deleted. According to European Commission reports (http://epp.eurostat.ec.europa.eu/), there are total around 200 life insurance companies registered in UK depending on the year. This is very close to the number of companies I have in my sample before deleting outliers and data recorded with mistakes, so the selection bias is not of much concern.

The variables I use in tests are recalculated in dollars and corrected for inflation. The main variables of the interest are proxies for premiums, and growth rates of number of policy contracts company sold. I calculate the premium as:

$$\pi = \ln(\frac{TotalCollectedPremium}{TotalClaims + Reserves_{t+1} - Reserves_t}), \qquad (3.1)$$

where $Reserves = TotalAssets - Shareholders'Funds - Debt$. For the growth rate of sales I use two proxies:

$$I)Growth_{1,t} = \ln(\frac{Reserves_t}{Reserves_{t-1}}) \qquad (3.2)$$

$$II)Growth_{2,t} = \ln\left(\frac{NetClaims_t + Reserves_t - Reserves_{t-1}}{Reserves_{t-1}}\right). \tag{3.3}$$

The first proxy indicates the number of new clients joined the company minus the number of old clients left the company, and the second proxy - only the number of new clients joined the company. The records with premium higher than 200%, and with growth rate higher than 200% are deleted. The other control variables are defined in the Appendix A. The summary statistics can be found in the Tables I, and II. I show the statistics of an aggregated sample, and sub-samples for Germany, Austria and UK. The majority of parameters in UK, Germany, and Austria are very similar, except size, and size related variables. On average the companies from the EU sample are considerably bigger.

3.2   Natural experiment in the UK life insurance industry

To test my theory, I use the 2004 announcement of new Risk Based Capital Adequacy Regulation (RBC) by the UK regulator as a natural experiment. New RBC regulation was a response to the wave of bankruptcies in 2000-2001, and was designed to decrease risk exposure of life insurance companies by increasing statutory capital levels.

   According to the PriceWaterHouseCoopers estimate performed in 2004, around 30% of insurance companies had to increase their capital levels to be able to continue their operations at the same scale under the new regulation. As a result the average solvency ratio increased from 9.4% before 2004 to 11.5% after 2004.

3.3   Does Hypotheses 1-4 apply?

To make predictions about the effect of the regulatory change on insurance premiums, we need to estimate the optimal solvency ratio,

$$s^* = \sqrt{-2\sigma^2 \ln\left(\frac{e\sigma\sqrt{2\pi}}{\delta}\right)},$$

   which depends on three parameters: volatility of profit σ, market imperfections δ, and agency costs of equity financed capital e. The values of the parameters used for estimation along with the estimate of the optimal solvency ratio can be found in the table 1:

Table 1: Estimation of the optimal solvency ratio

Description	Variable	Value
Volatility of profit	σ	8.5%
Market imperfections	δ	10%
Agency costs	e	10%
Optimal solvency ratio	s^*	14.9%

For the volatility of profit, I used the volatility of profitability (as profit by assets) of the UK sample after 2004 - 8.5%. For market imperfections, I used 10%. I based this parameter on my estimate(ref) of auto insurance market imperfections - 20%, but I chose a more conservative parameter to plug in. For the agency costs, I used 10%: I estimated the ratio of administrative expenses to capital for the UK subsample - 9.6%, and assumed that agency costs were comparable. The resulting optimal solvency ratio was 14.9%. Both, the average solvency ratio before 2004 (9.4%) and after 2004(11.5%), are below the optimal solvency ratio, and formally Hypotheses 1-4 are applicable.

3.4 Methodology and Empirical Results

This section of the chapter addresses the following question: Does the 2005 "tightening" of solvency regulation of the UK life insurance industry boost competition? As the benchmark regression specifications I employ a standard fixed effect approach traditionally used in natural experiment tests:

$$
\begin{aligned}
I)\pi_t = \Big[&\alpha_0 + \alpha_1 DM_{UK,2005-2007} + \alpha_2 Ln(Assets)_{t-1} + \alpha_3 Ln\left(\frac{Debt}{Assets}\right)_{t-1} + \\
&+\alpha_4 \left(\frac{Capital}{Assets}\right)_{t-1} + \alpha_5 \text{Rating}_t + \alpha_6 \text{GDP}_t + \alpha_7 \text{Wage}_t + \\
&+\alpha^*(Year, Country, ID) \Big],
\end{aligned}
\tag{3.4}
$$

and

$$
\begin{aligned}
II)\ \text{Growth}_{1or2,t} = \Big[&\beta_0 + \beta_1 DM_{UK,2005-2007} + \beta_2 Ln(Assets)_{t-1} + \beta_3 Ln\left(\frac{Debt}{Assets}\right)_{t-1} + \\
&+\beta_4 \left(\frac{Capital}{Assets}\right)_{t-1} + \beta_5 \text{Rating}_t + \beta_6 \text{GDP}_t + \beta_7 \text{Wage}_t + \beta^*(Year, Country, ID) \Big].
\end{aligned}
\tag{3.5}
$$

The left hand side variable in the model I) is the premium proxy, and in the model II) is the proxy for the growth of number of customers (or number of contracts). On the right hand side, the models have the dummy variable for treated sample, and a set of controlled variables. I consider the UK companies in year 2005 and after as "treated" by the new regulation, and German, Austrian, and France companies as the control sample.

The adoption of the new Risk Based Capital Regulation (RBC) was a long expected event. The Financial Services Authority (FSA), the regulator of the financial services industry in the UK, announced the first draft of the new regulation in 2002. The final version of RBC was published in July 2004, and was made active starting 2005. Since the UK insurance companies could respond immediately after announcement date, if not earlier, I tested alternative empirical models: A) where the treated sample is UK companies in year 2004 and after, and B) where companies in 2004 are excluded. The results of tests with A) and B) are comparable to ones with the benchmark regressions (19,20).

The other controlled variables in (19,20) are firm fixed effects, country fixed effects, year fixed effects, and a number of predetermined characteristics of the company typically used in financial empirical models.

Equations (19,20) are estimated using a panel regression with firm-fixed effects. The error terms in such type of models are typically correlated across firms. In this case, while the estimates of regression coefficients are unbiased, the t-statistics are overstated. I address this problem by calculating firm specific clustering in the standard fashion. The estimation procedure also corrects for potential heteroscedasticity across firms.

3.5   Benchmark Regression Results

I start discussion of the empirical results from sample properties. Fig. 2 shows median prices of treated (UK) and control (Germany, Austria, and France) samples. The control and the treated samples on average practically coincide before 2003-2004, but after 2004 we can see a decrease of average price for the UK life insurance industry. The observed result supports Hypothesis 1, predicting that the new RBC solvency regulation decreases insurance premiums.

Fig. 3 shows growth rates of treated (UK) and control (Germany, Austria, and France) samples. The control and the treated samples move synchronously for all years except 2004, where the treated sample demonstrates abnormal growth. The observed result supports Hypothesis 2, stating that the new RBC solvency regulation positively affects growth of the sales of the insurance contracts.

Column (1) of Table 3 shows the results for the benchmark specification given by equation (19,20). The estimated coefficient for the Dummy(UK,2005-2007) (that equals to 1 for UK companies after 2004, and 0 otherwise) captures the marginal effect of the new RBC regulation on premiums. The estimate of the Dummy coefficient is negative ($\alpha_1 = -0.31$) and significant at the 5% level, in agreement with Hypothesis 1.

Changes of premiums in the UK life insurance industry after 2004 can be driven by a change of demand, or can be influenced by overall economic conditions. To explore these alternative explanations of the observed effect, I add growth of Gross Domestic Product and Average Wage as controls to the benchmark specification (). Columns (2) and (3) show the estimates produced by the extended regressions. Column (3), besides Gross Domestic Product and Average Wage, has also lagged premium on the right hand side of the equation. The estimates of the Dummy coefficient from Columns (2) and (3) are negative, $\alpha_{1,specification2} = -0.48$ and $\alpha_{1,specification3} = -0.55$, and significant at the 1% level. The average estimate of the marginal effect of RBC regulation, $\alpha_{1,average} = -0.34$, is equivalent to an average decrease of premium by $26\% \pm 11\%$ in real terms.

Table 4 presents the results of the similar regression models but for the growth of the number of outstanding contracts. Columns (1), (2), and (3) show the estimates of the Dummy coefficients: $\beta_{1,specification1} = 0.067$, $\beta_{1,specification2} = 0.097$, and $\beta_{1,specification3} = 0.098$. The first estimate is not significant and the second and third are significant on the 5% levels. The average estimate of the RBC effect on the growth of the number of contract is $\beta_{1,average} = 0.086$, and it is equivalent to an increase of the growth rate in real terms by 11%. Columns (4), (5), and (6) repeats (1), (2), and (3), but with the second proxy for the growth rate of sales of the number of contracts rather than the total number of outstanding contracts. The estimates are: $\beta_{1,specification4} = 0.23$, $\beta_{1,specification5} = 0.50$, and $\beta_{1,specification6} = 0.54$. The third estimate is not significant and the fourth and fifth are significant at the 1% level. The not significant estimates are from the regressions where I do not control for GDP growth and for average wage. So it could be explain by mis-specification of the model. Other than that the results support Hypothesis 2.

3.6 Cross-sectional predictions: Methodology

According to the PriceWaterHouseCoopers estimate performed in 2004, around 30% of insurance companies had to increase their capital levels to be able to continue their operations at the same scale under the new regulation. If product market frictions theory is true, we should expect to see the relatively high drop of premiums specifically among these 30% low

capital companies because they are the ones who are directly affected by RBC. To measure the effect of RBC cross-sectionally, I extend the benchmark models by adding interaction term $y_{1,t-1} = DM_{UK,2005-2007} * \left(\frac{Capital}{Assets} \right)_{t-1}$ or $y_{2,t-1} = DM_{UK,2005-2007} * \left(\frac{Funds}{Assets} \right)_{t-1}$:

$$I) \pi_t = \left[\gamma_1 y_{t-1} + \alpha_0 + \alpha_1 DM_{UK,2005-2007} + \alpha_2 Ln(Assets)_{t-1} + \alpha_3 Ln \left(\frac{Debt}{Assets} \right)_{t-1} + \right.$$
$$\left. + \alpha_4 \left(\frac{Capital}{Assets} \right)_{t-1} + \alpha_5 \text{Rating}_t + \alpha_6 \text{GDP}_t + \alpha_7 \text{Wage}_t + \alpha^*(Year, Country, ID) \right],$$

and

$$II) \text{Growth}_{1or2,t} = \left[\gamma_2 y_{t-1} + \beta_0 + \beta_1 DM_{UK,2005-2007} + \beta_2 Ln(Assets)_{t-1} + \right.$$
$$+ \beta_3 Ln \left(\frac{Debt}{Assets} \right)_{t-1} + \beta_4 \left(\frac{Capital}{Assets} \right)_{t-1} + \beta_5 \text{Rating}_t + \beta_6 \text{GDP}_t + \beta_7 \text{Wage}_t +$$
$$\left. + \beta^*(Year, Country, ID) \right],$$

where $y_{1,t}$ and $y_{2,t}$ are two proxies for the interaction term. The difference between them is that in first case I use only Capital to calculate the solvency ratio, and in the second case I use Capital + Voluntary Reserves = Funds. Hypotheses 3 and 4 predicts that $\gamma_1 > 0$ and $\gamma_2 < 0$.

3.7 Cross-sectional predictions: Results

Table 5 and Table 7 demonstrate the results of the cross-sectional regressions for premiums. Regressions of Table 5 uses proxy for the interaction term y_1 based only on Capital, and Table 6 uses proxy for the interaction term y_2 based on Capital and Voluntary reserves. The estimates of the interaction term effect γ_1 are all positive, but significant only for some of regressions with second proxy y_2. Table 7 and Table 9 similarly present the results of the cross-sectional tests for the growth of the number of contracts. The estimates of the interaction terms γ_2 are all negative, but significant only for some of the regressions with the first proxy y_1. The signs of the estimates are always in agreement with Hypotheses 3 and 4. Overall tests are support or do not reject Hypotheses 3 and 4. The low statistical significance of the estimates for the interaction term can be explained by the data limitations. There are only around 150 insurance companies in the UK sample.

Chapter 4

Conclusions

This thesis suggests a model of the effect of solvency regulation on the product market competition. The model embeds two counteracting mechanisms: the traditional effect of costs of equity financing on pricing behavior, and the Chevalier-Scharfstein (C-S) effect of product market frictions on product market decisions. This is the first time in the literature that the C-S idea was applied to financial intermediaries, providing a number of novel predictions about the capital minimum that regulates capital structure of insurance companies.

The model predicts that the equilibrium premium is a "U"-shaped function of capital minimum. If the capital minimum is small enough, "tightening" of solvency regulation would motivate insurers to decrease premiums, and to increase clientele. This prediction of the model challenges the conventional wisdom that capital minimum increases costs of equity financing and hurts competition.

To test the prediction of the theory, the thesis provides a study of the adoption of the new RBC solvency regulation by UK in 2004. The new RBC regulation leads to the increase of capital levels from 9.4% to 11.5%, while the optimal capital level that minimizes the premium is estimated as 14.9%. The theory suggested in the thesis predicts that the RBC regulation should lead to a lower premium and to a larger number of customers.

The effect of RBC on premiums and on numbers of clients is measured with the help of fixed effect regressions. The estimates of this effect are significant and in real terms are equivalent to the 26% decrease of premium and the 11% increase of the number of total customers. This empirical evidence supports my theory, implying that product market frictions are an important element for understanding the effect of capital structure on product market competition and efficiency. In light of the adoption of the new Solvency II EU reg-

ulation on January 1, 2013, presented empirical findings open a new area for policy related research .

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Appendix A

Definition of control variables

The control variables are defined as the following:

$DM_{UK,2005-2007}$ equals to one for UK insurance companies and for years 2005-2007.

$Ln(Assets)_{t-1}$ is the proxy for Size.

$Ln\left(\frac{Debt}{Assets}\right)_{t-1}$ is the proxy for debt leverage ratio.

$\left(\frac{Capital}{Assets}\right)_{t-1}$ is the proxy for solvency ratio.

$Rating_t$ is the reliability rating assign by agency.

GDP_t is the growth of Gross Domestic Product of the country.

$Wage_t$ is the average wage of the country.

Year are dummy variables to control for year fixed effects.

Country are dummy variables to control for country fixed effects.

ID are dummy variables to control for ID fixed effects.

Appendix B

Tables

Number of observations	4231			
	Mean	Std. Deviation	Min	Max
Debt	171485.7	876212.3	0	1.02e
Claims	422216.4	1264883	0.490324	3.19e
Premium	657868.2	1937547	-15301	5.49e
Investment Return	4.732891	2.457911	0.04	40
Investment Yield	4.490385	4.804868	-38.13	101.7
Profit before taxes	46932.62	228351	-394894	6682506
Solvency	8.055902	10.82372	-0.12	91.3
Assets	6276223	2.86e	23.39623	8.47e
Wage	37.89459	3.851037	28.9	53.2
Size	13.20262	2.808459	3.152575	20.55682
Growth	1.28935	0.485097	0.267873	3.984138
Profitability	-0.00426	0.834121	-53.749	4.763379
Leverage	0.002881	0.010327	0	0.098013

Table B.1: Sample Data source is Bureau Van Dijk ISIS data base.

The sample period is 1997-2007.
Variable definitions:
$$\text{Solvency}_t = ShareholdersFunds_t/TotalAssets_t$$
$$\text{Size}_t = log(Assets)_t$$
$$\text{Growth}_t = \frac{Claims_t}{Claims_{t-1}}$$
$$\text{Profitability}_t = \frac{Profit_t}{Assets_t}$$
$$\text{Leverage}_t = \frac{Debt_t}{Assets_t}$$

	United Kingdom		Germany		Austria	
Variable	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
Number of observations	886		1794		264	
Debt	5965.777	23658.77	37423.7	82020.19	20044.05	41690.43
Claims	126490.5	380795.8	485444.3	1135752	170042	239267.1
Premium	158153.8	450503.4	674459.6	1366137	277811.3	365780.5
Investment Return	3.995023	1.623739	5.353935	1.567532	5.180606	1.599394
Investment Yield	5.008352	8.239477	4.963991	2.676589	3.423371	1.330279
Profit before taxes	6672.641	46550.94	19963.95	68049.05	21952	49624.75
Solvency	9.386896	13.361	6.350541	11.33704	9.987008	7.927486
Assets	1259498	3303613	5763820	1.35e	2784237	3679833
Wage	38.70617	4.676326	37.02648	1.879465	36.32231	0.979072
Size	11.0282	2.779942	13.91706	2.176222	14.04444	1.377029
Growth	1.237843	0.510444	1.255033	0.42929	1.213165	0.386971
Profitability	-0.04563	1.820947	0.002798	0.033153	0.008868	0.01567
Leverage	0.005331	0.014129	0.000709	0.003625	0.001182	0.002833

Table B.2: Sample, countries. Data source is Bureau Van Dijk ISIS data base. The sample period is 1997-2007.

Variable definitions:

$$\text{Solvency}_t = Shareholders Funds_t / Total Assets_t$$
$$\text{Size}_t = log(Assets)_t$$
$$\text{Growth}_t = \frac{Claims_t}{Claims_{t-1}}$$
$$\text{Profitability}_t = \frac{Profit_t}{Assets_t}$$
$$\text{Leverage}_t = \frac{Debt_t}{Assets_t}$$

Table B 3, The effect of RBC solvency regulation on premiums

This table shows results of the baseline fixed effect regressions for premiums. The estimated model is (or similar to):

$$\pi_t = \left[\alpha_0 + \alpha_1 DM_{UK,2005-2007} + \alpha_2 Ln(Assets)_{t-1} + \alpha_3 Ln\left(\frac{Debt}{Assets}\right)_{t-1} + \right.$$

$$\left. + \alpha_4 \left(\frac{Capital}{Assets}\right)_{t-1} + \alpha_5 \text{Rating}_t + \alpha_6 \text{GDP}_t + \alpha_7 \text{Wage}_t + \alpha_i Year + \alpha_j Country + \alpha_k ID \right]. \quad \text{(B.1)}$$

The left hand side variable is:

$$\pi = ln\left(\frac{TotalCollectedPremium}{TotalClaims + Reserves_{t+1} - Reserves_t}\right),$$

$$\text{(B.2)}$$

where $Reserves = TotalAssets - Shareholders'Funds - Debt$.

The right hand side variables are:

$DM_{UK,2005-2007}$ equals to one for UK insurance companies and for years 2005-2007.

$Ln(Assets)_{t-1}$ is the proxy for Size.

$Ln\left(\frac{Debt}{Assets}\right)_{t-1}$ is the proxy for debt leverage ratio.

$\left(\frac{Capital}{Assets}\right)_{t-1}$ is the proxy for solvency ratio.

Rating_t is the reliability rating assign by agency.

GDP_t is the growth of Gross Domestic Product of the country.

Wage_t is the average wage of the country.

Year are dummy variables to control for year fixed effects.

Country are dummy variables to control for country fixed effects.

ID are dummy variables to control for ID fixed effects.

The sample contains data from 1997 till 2007 years, for United Kingdom, Germany, Austria, France. The "treated" sample is the UK companies. Financial reports of insurance companies from Germany, Austria, and France are used as a control sample. The t-statistic is calculated for firm-clustered errors to correct for the firm-specific time-series correlation of the error term. The results of the table allow us to test Hypothesis 1 stating that the effect of RBC regulation on premiums should be negative: $\alpha_1 < 0$.

		π_t	
	—————	—————	—————
	(1)	(2)	(3)
$DM_{UK,2005-2007}$	-0.309*	-0.482***	-0.551***
	(-2.32)	(-3.44)	(-4.39)
π_{t-1}			0.0171
			(0.63)
GDP_t		0.0628***	0.0522**
		(3.53)	(2.7)
Wage_t		0.0861***	0.0724***
		(7.12)	(5.32)
$Ln(Assets)_{t-1}$	0.159***	0.162**	0.171**
	(3.62)	(3.28)	(3.06)
$Ln\left(\frac{Debt}{Assets}\right)_{t-1}$	1.099	1.009	1.116
	(0.68)	(0.65)	(0.64)
$Ln\left(\frac{Profit}{Assets}\right)_{t-1}$	-0.00195	-0.00408	-0.153***
	(-0.54)	(-1.04)	(-4.48)
$\left(\frac{Capital}{Assets}\right)_{t-1}$	0.00354	0.0032	0.00155
	(1.2)	(1.03)	(0.36)
Rating_{t-1}	0.00123	0.0015	-0.00117*
	(1.71)	(1.94)	(-2.21)
Country	X	X	X
Year	X	X	X
ID	X	X	X
Constant	-1.679***	-6.340***	-6.034***
	(-3.44)	(-6.76)	(-5.72)
N	3356	2870	2484
adj. R-sq	0.675	0.693	0.725

t statistics in parentheses

Table B.3: The effect of RBC solvency regulation on premiums

Table B 4, The effect of RBC solvency regulation on the growth of the total number of customers
This table shows results of the baseline fixed effect regressions for the growth. The estimated model is (or similar to):

$$Growth_{1or2,t} = \Bigg[\beta_0 + \beta_1 DM_{UK,2005-2007} + \beta_2 Ln(Assets)_{t-1} + \beta_3 Ln\left(\frac{Debt}{Assets}\right)_{t-1} +$$

$$+\beta_4 \left(\frac{Capital}{Assets}\right)_{t-1} + \beta_5 \text{Rating}_t + \beta_6 \text{GDP}_t + \beta_7 \text{Wage}_t + \beta_i Year + \beta_j Country + \beta_k ID \Bigg]. \qquad (B.2)$$

The left hand side variables are:

$$I)Growth_{1,t} = ln(\frac{Reserves_t}{Reserves_{t-1}}), \qquad (B.3)$$

or

$$II)Growth_{2,t} = ln(\frac{NetClaims_t + Reserves_t - Reserves_{t-1}}{Reserves_{t-1}}). \qquad (B.4)$$

The right hand side variables are:

1) $DM_{UK,2005-2007}$ equals to one for UK insurance companies and for years 2005-2007.

2) $Ln(Assets)_{t-1}$ is the proxy for Size.

3) $Ln\left(\frac{Debt}{Assets}\right)_{t-1}$ is the proxy for debt leverage ratio.

4) $\left(\frac{Capital}{Assets}\right)_{t-1}$ is the proxy for solvency ratio.

5) Rating_t is the reliability rating assign by agency.

6) GDP_t is the growth of Gross Domestic Product of the country.

7) Wage_t is the average wage of the country.

8) Year are dummy variables to control for year fixed effects.

9) Country are dummy variables to control for country fixed effects.

10) ID are dummy variables to control for ID fixed effects.

The sample contains data from 1997 till 2007 years, for United Kingdom, Germany, Austria, France. The "treated" sample is the UK companies. Financial reports of insurance companies from Germany, Austria, and France are used as a control sample. The t-statistic is calculated for firm-clustered errors to correct for the firm-specific time-series correlation of the error term. The results of the table allow us to test Hypothesis 2 stating that the effect of RBC regulation on the growth of total number of customers should be positive: $\beta_1 > 0$.

	Growth$_{1,t}$			Growth$_{2,t}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$DM_{UK,2005-2007}$	0.0696	0.0974*	0.0978*	0.234	0.503**	0.539**
	(1.8)	(2.39)	(2.49)	(1.36)	(2.65)	(2.62)
Growth$_{1,t}$			0.0721*			
			(2.48)			
Growth$_{2,t}$						0.0289
						(1.04)
GDP$_t$		-0.0163*	-0.0116		-0.0395	0.0105
		(-2.31)	(-1.73)		(-1.55)	(0.38)
Wage$_t$		-0.0194***	-0.0197***		-0.104***	-0.107**
		(-5.32)	(-5.18)		(-5.91)	(-5.55)
$Ln(Assets)_{t-1}$	-0.183***	-0.154***	-0.147***	-0.715***	-0.678***	-0.649**
	(-8.35)	(-7.13)	(-6.12)	(-9.60)	(-8.75)	(-7.86)
$Ln\left(\frac{Debt}{Assets}\right)_{t-1}$	1.253*	1.273	1.08	4.213	5.019	6.462
	(2.02)	(1.95)	(1.45)	(1.51)	(1.76)	(1.78)
$Ln\left(\frac{Profit}{Assets}\right)_{t-1}$	0.000466	0.000736	-0.172	-0.001	0.00186	-0.347
	(1.05)	(1.6)	(-1.58)	(-0.44)	(0.84)	(-0.64)
$\left(\frac{Capital}{Assets}\right)_{t-1}$	0.00266	0.00316*	0.00396*	0.0118	0.0114	0.0167*
	(1.69)	(1.99)	(2.32)	(1.7)	(1.69)	(2.06)
Rating$_{t-1}$	-0.00260***	0.00330***	-0.00231***	-0.0123***	-0.0119***	0.0122**
	(-6.33)	(7.73)	(-5.36)	(-9.19)	(-8.63)	(7.87)
Country	X	X	X	X	X	X
Year	X	X	X	X	X	X
ID	X	X	X	X	X	X
Constant	2.272***	2.264***	2.573***	9.000***	10.20***	7.631**
	(8.39)	(8.63)	(8.13)	(7.98)	(9.43)	(7.06)
N	4286	3724	3458	4013	3465	2965
adj. R-sq	0.558	0.573	0.584	0.589	0.6	0.613

t statistics in parentheses

Table B.4: The effect of RBC solvency regulation on the growth of the number of customers

$Table B5, The effect of RBC solvency regulation on premiums : Cross-sectional difference$

This table shows results of the baseline fixed effect regressions for premiums. The estimated model is (or similar to):

$$\pi_t = \left[\gamma_1 y_{1,t-1} + \alpha_0 + \alpha_1 DM_{UK,2005-2007} + \alpha_2 Ln(Assets)_{t-1} + \alpha_3 Ln\left(\frac{Debt}{Assets}\right)_{t-1} + \right.$$

$$\left. + \alpha_4 \left(\frac{Capital}{Assets}\right)_{t-1} + \alpha_5 \text{Rating}_t + \alpha_6 \text{GDP}_t + \alpha_7 \text{Wage}_t + \alpha_i Year + \alpha_j Country + \alpha_k ID \right]. \quad \text{(B.4)}$$

The left hand side variable is:

$$\pi = ln\left(\frac{TotalCollectedPremium}{TotalClaims + Reserves_{t+1} - Reserves_t}\right),$$

(B.4)

where $Reserves = TotalAssets - Shareholders'Funds - Debt.$
The right hand side variables are:

1) $DM_{UK,2005-2007}$ equals to one for UK insurance companies and for years 2005-2007.

2) $Ln(Assets)_{t-1}$ is the proxy for Size.

3) $Ln\left(\frac{Debt}{Assets}\right)_{t-1}$ is the proxy for debt leverage ratio.

4) $\left(\frac{Capital}{Assets}\right)_{t-1}$ is the proxy for solvency ratio.

5) Rating_t is the reliability rating assign by agency.

6) GDP_t is the growth of Gross Domestic Product of the country.

7) Wage_t is the average wage of the country.

8) Year are dummy variables to control for year fixed effects.

9) Country are dummy variables to control for country fixed effects.

10) ID are dummy variables to control for ID fixed effects.

11) $y_{1,t-1} = DM_{UK,2005-2007} * \left(\frac{Capital}{Assets}\right)_{t-1}$ the interaction term

The sample contains data from 1997 till 2007 years, for United Kingdom, Germany, Austria, France. The "treated" sample is the UK companies. Financial reports of insurance companies from Germany, Austria, and France are used as a control sample. The t-statistic is calculated for firm-clustered errors to correct for the firm-specific time-series correlation of the error term. The results of the table allow us to test Hypothesis 1 stating that the effect of RBC regulation on premiums should be negative: $\alpha_1 < 0$.

		π_t	
	(1)	(2)	(3)
$DM_{UK,2005-2007}$	-0.512**	-0.675***	-0.584***
	(-2.75)	(-4.19)	(-3.75)
$y_{1,t-1}$	0.131	0.124	0.022
	(1.56)	(1.57)	(0.32)
π_{t-1}			0.0168
			(0.62)
GDP_t		0.0627***	0.0521**
		(3.52)	(2.7)
$Wage_t$		0.0858***	0.0723***
		(7.05)	(5.28)
$Ln(Assets)_{t-1}$	0.158***	0.160**	0.170**
	(3.49)	(3.16)	(3.05)
$Ln\left(\frac{Debt}{Assets}\right)_{t-1}$	1.102	1.017	1.114
	(0.68)	(0.65)	(0.64)
$Ln\left(\frac{Profit}{Assets}\right)_{t-1}$	-0.00182	-0.00398	-0.153***
	(-0.52)	(-1.03)	(-4.49)
$\left(\frac{Capital}{Assets}\right)_{t-1}$	0.0033	0.00296	0.00152
	(1.14)	(0.95)	(0.35)
$Rating_{t-1}$	0.00123	0.0015	-0.00116*
	(1.69)	(1.9)	(-2.21)
Country	X	X	X
Year	X	X	X
ID	X	X	X
Constant	-2.195***	-4.763***	-5.184***
	(-4.37)	(-6.41)	(-6.63)
N	3353	2867	2482
adj. R-sq	0.676	0.693	0.725

t statistics in parentheses

Table B.5: The effect of RBC solvency regulation on premiums: Cross-sectional difference

Table B 6, The effect of RBC solvency regulation on the growth of the total number of customers: Cross-sectional difference

This table shows results of the baseline fixed effect regressions for the growth. The estimated model is (or similar to):

$$Growth_{1 or 2,t} = \left[\gamma_2 y_{1,t-1} + \beta_0 + \beta_1 DM_{UK,2005-2007} + \beta_2 Ln(Assets)_{t-1} + \beta_3 Ln\left(\frac{Debt}{Assets}\right)_{t-1} + \right.$$

$$\left. + \beta_4 \left(\frac{Capital}{Assets}\right)_{t-1} + \beta_5 \text{Rating}_t + \beta_6 \text{GDP}_t + \beta_7 \text{Wage}_t + \beta_i Year + \beta_j Country + \beta_k ID \right]. \qquad \text{(B.3)}$$

The left hand side variables are:

$$I) Growth_{1,t} = ln(\frac{Reserves_t}{Reserves_{t-1}}), \qquad \text{(B.4)}$$

or

$$II) Growth_{2,t} = ln(\frac{NetClaims_t + Reserves_t - Reserves_{t-1}}{Reserves_{t-1}}). \qquad \text{(B.5)}$$

The right hand side variables are:

1) $DM_{UK,2005-2007}$ equals to one for UK insurance companies and for years 2005-2007.

2) $Ln(Assets)_{t-1}$ is the proxy for Size.

3) $Ln\left(\frac{Debt}{Assets}\right)_{t-1}$ is the proxy for debt leverage ratio.

4) $\left(\frac{Capital}{Assets}\right)_{t-1}$ is the proxy for solvency ratio.

5) Rating_t is the reliability rating assign by agency.

6) GDP_t is the growth of Gross Domestic Product of the country.

7) Wage_t is the average wage of the country.

8) Year are dummy variables to control for year fixed effects.

9) Country are dummy variables to control for country fixed effects.

10) ID are dummy variables to control for ID fixed effects.

11) $y_{1,t-1} = DM_{UK,2005-2007} * \left(\frac{Capital}{Assets}\right)_{t-1}$ the interaction term

The sample contains data from 1997 till 2007 years, for United Kingdom, Germany, Austria, France. The "treated" sample is the UK companies. Financial reports of insurance companies from Germany, Austria, and France are used as a control sample. The t-statistic is calculated for firm-clustered errors to correct for the firm-specific time-series correlation of the error term. The results of the table allow us to test Hypothesis 2 stating that the effect of RBC regulation on the growth of total number of customers should be positive: $\beta_1 > 0$.

	$Growth_{1,t}$			$Growth_{2,t}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$DM_{UK,2005-2007}$	0.121*	0.151**	0.148**	0.759**	1.028***	1.069**
	(2.26)	(2.89)	(3.14)	(3.2)	(4.48)	(4.27)
$y_{1,t-1}$	-0.0423	-0.0436	-0.0391	-0.357**	-0.357**	-0.365*
	(-1.54)	(-1.63)	(-1.58)	(-2.59)	(-2.65)	(-2.44)
$Growth_{1,t}$			0.0653*			
			(2.3)			
$Growth_{2,t}$						0.0224
						(0.85)
GDP_t		-0.0165*	-0.0119		-0.0413	0.0098
		(-2.33)	(-1.78)		(-1.63)	(0.36)
$Wage_t$		-0.0199***	-0.0203***		-0.105***	-0.109**
		(-5.53)	(-5.43)		(-5.99)	(-5.65)
$Ln(Assets)_{t-1}$	-0.184***	-0.155***	-0.147***	-0.721***	-0.687***	-0.661**
	(-8.17)	(-6.96)	(-6.00)	(-9.27)	(-8.45)	(-7.48)
$Ln\left(\frac{Debt}{Assets}\right)_{t-1}$	1.277*	1.276	1.06	4.594	5.482	7.348
	(1.97)	(1.85)	(1.35)	(1.56)	(1.81)	(1.87)
$Ln\left(\frac{Profit}{Assets}\right)_{t-1}$	0.000462	0.000752	-0.167	-0.00108	0.00181	-0.418
	(1.05)	(1.67)	(-1.50)	(-0.46)	(0.79)	(-0.80)
$Ln\left(\frac{Capital}{Assets}\right)_{t-1}$	0.00277	0.00343	0.00437*	0.0116	0.0108	0.0169
	(1.49)	(1.8)	(2.13)	(1.43)	(1.35)	(1.56)
$Rating_{t-1}$	0.00390***	0.00332***	-0.00233***	-0.0124***	-0.0120***	0.0129**
	(8.92)	(7.73)	(-5.42)	(-8.93)	(-8.38)	(7.95)
Country	X	X	X	X	X	X
Year	X	X	X	X	X	X
ID	X	X	X	X	X	X
Constant	1.959***	3.397***	2.397***	7.052***	13.47***	7.769**
	(7.75)	(9.14)	(7.3)	(7.29)	(9.53)	(6.64)
N	4284	3722	3456	4011	3463	2963
adj. R-sq	0.561	0.577	0.588	0.593	0.605	0.618

t statistics in parentheses

Table B.6: The effect of RBC solvency regulation on the growth of the number of customers: Cross-sectional difference

$Table B7, The effect of RBC solvency regulation on premiums : Cross-sectional difference$

This table shows results of the baseline fixed effect regressions for premiums. The estimated model is (or similar to):

$$\pi_t = \left[\gamma_1 y_{2,t-1} + \alpha_0 + \alpha_1 DM_{UK,2005-2007} + \alpha_2 Ln(Assets)_{t-1} + \alpha_3 Ln\left(\frac{Debt}{Assets}\right)_{t-1} + \right.$$

$$\left. + \alpha_4 \left(\frac{Capital}{Assets}\right)_{t-1} + \alpha_5 \text{Rating}_t + \alpha_6 \text{GDP}_t + \alpha_7 \text{Wage}_t + \alpha_i Year + \alpha_j Country + \alpha_k ID \right]. \quad \text{(B.5)}$$

The left hand side variable is:

$$\pi = ln\left(\frac{Total Collected Premium}{Total Claims + Reserves_{t+1} - Reserves_t}\right),$$

(B.5)

where $Reserves = Total Assets - Shareholders' Funds - Debt$.

The right hand side variables are:

1) $DM_{UK,2005-2007}$ equals to one for UK insurance companies and for years 2005-2007.

2) $Ln(Assets)_{t-1}$ is the proxy for Size.

3) $Ln\left(\frac{Debt}{Assets}\right)_{t-1}$ is the proxy for debt leverage ratio.

4) $\left(\frac{Capital}{Assets}\right)_{t-1}$ is the proxy for solvency ratio.

5) Rating_t is the reliability rating assign by agency.

6) GDP_t is the growth of Gross Domestic Product of the country.

7) Wage_t is the average wage of the country.

8) Year are dummy variables to control for year fixed effects.

9) Country are dummy variables to control for country fixed effects.

10) ID are dummy variables to control for ID fixed effects.

11) $y_{2,t-1} = DM_{UK,2005-2007} * \left(\frac{Funds}{Assets}\right)_{t-1}$ the interaction term.

The sample contains data from 1997 till 2007 years, for United Kingdom, Germany, Austria, France. The "treated" sample is the UK companies. Financial reports of insurance companies from Germany, Austria, and France are used as a control sample. The t-statistic is calculated for firm-clustered errors to correct for the firm-specific time-series correlation of the error term. The results of the table allow us to test Hypothesis 1 stating that the effect of RBC regulation on premiums should be negative: $\alpha_1 < 0$.

	(1)	π_t (2)	(3)
DM$_{UK,2005-2007}$	-0.562***	-0.703***	-0.685***
	(-3.63)	(-4.39)	(-4.15)
y$_{2,t-1}$	0.408**	0.342*	0.241
	(2.7)	(2.3)	(1.71)
π_{t-1}			0.00702
			(0.23)
GDP$_t$		0.0629***	0.0603**
		(3.43)	(3.07)
Wage$_t$		0.0904***	0.0769***
		(7.13)	(5.24)
$Ln(Assets)_{t-1}$	0.149**	0.147**	0.158**
	(3.25)	(2.84)	(2.78)
$Ln\left(\frac{Debt}{Assets}\right)_{t-1}$	0.681	0.562	0.783
	(0.43)	(0.33)	(0.44)
$Ln\left(\frac{Profit}{Assets}\right)_{t-1}$	-0.00191	-0.00459	-0.162***
	(-0.54)	(-1.20)	(-4.63)
$\left(\frac{Capital}{Assets}\right)_{t-1}$	0.00273	0.00252	0.000229
	(0.94)	(0.8)	(0.05)
Rating$_{t-1}$	0.000898	0.000556	1.03E-05
	(1.12)	(0.67)	(0.01)
Country	X	X	X
Year	X	X	X
ID	X	X	X
Constant	-1.988***	-6.205***	-5.955***
	(-3.90)	(-6.24)	(-5.40)
N	2775	2305	2010
adj. R-sq	0.653	0.673	0.706

t statistics in parentheses

Table B.7: The effect of RBC solvency regulation on premiums: Cross-sectional difference

Table B 8, The effect of RBC solvency regulation on the growth of the total number of customers: Cross-sectional difference 2

This table shows results of the baseline fixed effect regressions for the growth. The estimated model is (or similar to):

$$Growth_{1or2,t} = \left[\gamma_2 y_{2,t-1} + \beta_0 + \beta_1 DM_{UK,2005-2007} + \beta_2 Ln(Assets)_{t-1} + \beta_3 Ln\left(\frac{Debt}{Assets}\right)_{t-1} + \right.$$

$$\left. +\beta_4\left(\frac{Capital}{Assets}\right)_{t-1} + \beta_5 \text{Rating}_t + \beta_6 \text{GDP}_t + \beta_7 \text{Wage}_t + \beta_i Year + \beta_j Country + \beta_k ID \right]. \qquad (B.4)$$

The left hand side variables are:

$$I) Growth_{1,t} = ln(\frac{Reserves_t}{Reserves_{t-1}}), \qquad (B.5)$$

or

$$II) Growth_{2,t} = ln(\frac{NetClaims_t + Reserves_t - Reserves_{t-1}}{Reserves_{t-1}}). \qquad (B.6)$$

The right hand side variables are:

1) $DM_{UK,2005-2007}$ equals to one for UK insurance companies and for years 2005-2007.

2) $Ln(Assets)_{t-1}$ is the proxy for Size.

3) $Ln\left(\frac{Debt}{Assets}\right)_{t-1}$ is the proxy for debt leverage ratio.

4) $\left(\frac{Capital}{Assets}\right)_{t-1}$ is the proxy for solvency ratio.

5) Rating_t is the reliability rating assign by agency.

6) GDP_t is the growth of Gross Domestic Product of the country.

7) Wage_t is the average wage of the country.

8) Year are dummy variables to control for year fixed effects.

9) Country are dummy variables to control for country fixed effects.

10) ID are dummy variables to control for ID fixed effects.

11) $y_{2,t-1} = DM_{UK,2005-2007} * \left(\frac{Funds}{Assets}\right)_{t-1}$ the interaction term.

The sample contains data from 1997 till 2007 years, for United Kingdom, Germany, Austria, France. The "treated" sample is the UK companies. Financial reports of insurance companies from Germany, Austria, and France are used as a control sample. The t-statistic is calculated for firm-clustered errors to correct for the firm-specific time-series correlation of the error term. The results of the table allow us to test Hypothesis 2 stating that the effect of RBC regulation on the growth of total number of customers should be positive: $\beta_1 > 0$.

	$Growth_{1,t}$			$Growth_{2,t}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$DM_{UK,2005-2007}$	0.102	0.121*	0.132*	0.392	0.621*	0.668*
	(1.77)	(2.06)	(2.22)	(1.66)	(2.46)	(2.44)
$y_{2,t-1}$	-0.0426	-0.0336	-0.0451	-0.217	-0.178	-0.211
	(-1.29)	(-1.02)	(-1.28)	(-1.39)	(-1.13)	(-1.25)
$Growth_{1,t}$			0.0700*			
			(2.22)			
$Growth_{2,t}$						0.0398
						(1.31)
GDP_t		-0.0181*	-0.0133		-0.0412	0.00999
		(-2.32)	(-1.81)		(-1.40)	(0.32)
$Wage_t$		-0.0200***	-0.0201***		-0.103***	-0.101**
		(-4.99)	(-4.81)		(-5.61)	(-5.19)
$Ln(Assets)_{t-1}$	-0.184***	-0.154***	-0.148***	-0.713***	-0.673***	-0.642**
	(-7.48)	(-6.35)	(-5.52)	(-8.82)	(-7.99)	(-7.02)
$Ln\left(\frac{Debt}{Assets}\right)_{t-1}$	1.609*	1.510*	1.217	7.237**	7.272**	7.938*
	(2.37)	(2.04)	(1.4)	(3.02)	(2.73)	(2.22)
$Ln\left(\frac{Profit}{Assets}\right)_{t-1}$	0.00056	0.00094	-0.177	-0.00027	0.00313	-0.589
	(1.13)	(1.87)	(-1.55)	(-0.11)	(1.28)	(-0.92)
$\left(\frac{Capital}{Assets}\right)_{t-1}$	0.00224	0.00327	0.00408	0.00547	0.00694	0.0123
	(1.08)	(1.54)	(1.78)	(0.67)	(0.82)	(1.12)
$Rating_{t-1}$	0.00384***	0.00326***	-0.00233***	0.0142***	-0.0102***	0.0117**
	(7.98)	(6.91)	(-4.97)	(8.82)	(-6.43)	(7.05)
Country	X	X	X	X	X	X
Year	X	X	X	X	X	X
ID	X	X	X	X	X	X
Constant	2.832***	3.209***	3.265***	8.807***	9.370***	7.534**
	(7.65)	(7.71)	(7.12)	(7.28)	(7.84)	(6.2)
N	3442	2901	2692	3253	2724	2351
adj. R-sq	0.538	0.552	0.56	0.574	0.577	0.595

t statistics in parentheses

Table B.8: The effect of RBC solvency regulation on the growth of the number of customers: Cross-sectional difference 2
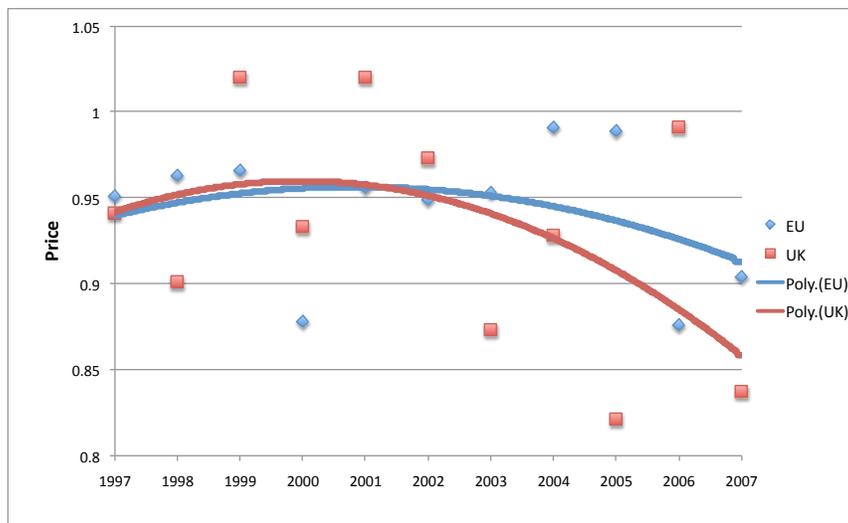
Appendix C

Graphs

Figure C.1: The prices are calculated as a ratio of total premium to total claims; the graphs shows the median price of the UK subsample and control subsample (Germany, Austria, France). One can notice the decrease of an average price level in the UK after 2003-2004. This result supports Hypothesis 1 stating that RBC regulation should negatively affect insurance premiums.
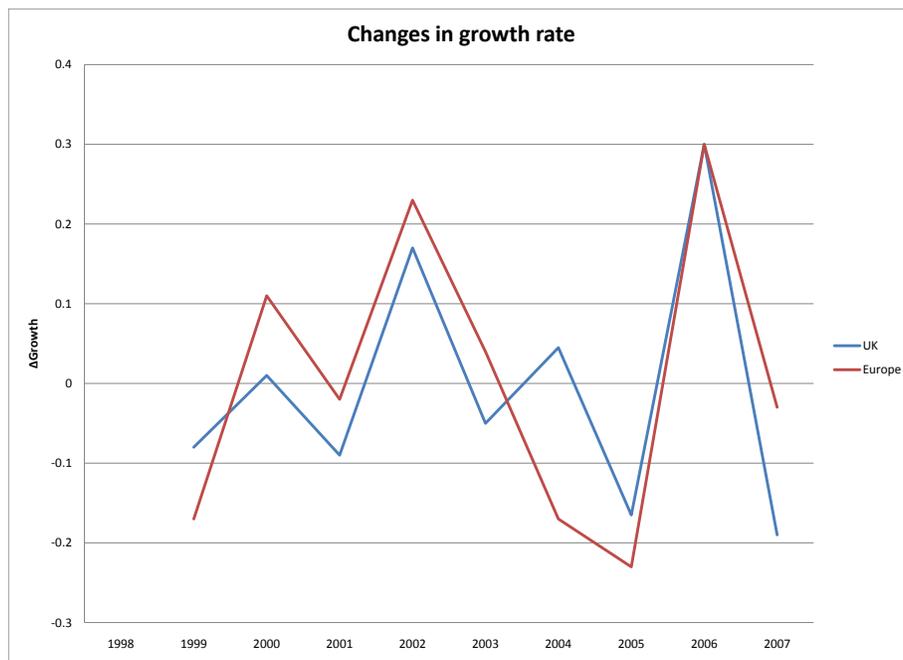
Figure C.2: The growth rate is calculated as a ratio of total claims at time t to total claims at time t-1; the graphs shows the median change of the growth rate of the UK subsample and control subsample (Germany, Austria, France). There is an evidence of one deviation of the change of median growth rate in the UK from the median growth rate in the control sample in 2004. This result supports Hypothesis 2 predicting that RBC solvency regulation should positively affect the growth of the number of contracts.