2. Model and Variables

2.1 Model Specification

In order to discuss the relationship between capital ratios and risk, we use a simultaneous equations model, developed by Shrieves and Dahl (1992), which is also used by CS and BS. The differences in our model are the addition of a regulatory variable – the RBC ratio that is presumed to affect an insurance firm's capital ratio and risk.

CS uses a simultaneous equations model to investigate the capital and portfolio risk decisions by property-liability companies. BS uses the same model to examine the interrelationship amongst capital, asset risk, and product risk in the life insurance industry. An insurance firm's value is decided by two main endogenous parameters, the capital ratio and risk, which includes both asset risk and product risk. Exogenous factors and the regulatory pressure from the previous year's regulations affect capital and risk. Thus, changes in capital and risk can be written as follows:

$$\Delta CAP_{j,t} = \Delta CAP_{j,t}^{D} + \alpha^{RV} RV_{j,t-1} + \varepsilon_{j,t}^{C} \quad (1)$$

$$\Delta RISK_{j,t} = \Delta RISK_{j,t}^{D} + \gamma^{RV} RV_{j,t-1} + \varepsilon_{j,t}^{R} \quad (2)$$

where

$\Delta CAP_{j,t}$ = the change in capital-to-asset ratio of firm j from time t-1 to t,

$\Delta RISK_{j,t}$ = the change in the risk of firm j from time t-1 to t,

$\Delta CAP^{D}_{j,t}$ = the endogenously determined adjustment to capital from time t-1 to t,

$\Delta RISK^{D}_{j,t}$ = the endogenously determined adjustment to risk from time t-1 to t,

$RV_{j,t-1}$ = the regulatory variable of firm j at time t-1,

$\varepsilon^{C}_{j,t}$, $\varepsilon^{R}_{j,t}$ = the exogenous adjustments in capital and risk from time t-1 to t.

The endogenous components of the change in the capital ratio and risk are proportional to the difference between the insurer's target values of these variables and their values at the end of the preceding period:

$$\Delta CAP_{j,t} = \alpha[CAP^{*}_{j,t} - CAP_{j,t-1}] + \alpha^{RV} RV_{j,t-1} + \varepsilon^{C}_{j,t} \tag{3}$$

$$\Delta RISK_{j,t} = \gamma[RISK^{*}_{j,t} - RISK_{j,t-1}] + \gamma^{RV} RV_{j,t-1} + \varepsilon^{R}_{j,t} \tag{4}$$

where

$CAP^{*}_{j,t}$ = the insurance firm j's target capital-to-asset ratio at time t,

$RISK^{*}_{j,t}$ = the insurance firm j's target risk at time t,

$\varepsilon^{C}_{j,t}$, $\varepsilon^{R}_{j,t}$ = adjustment coefficients.

There are many factors, which affect a insurance firm's target capital-to-asset ratio and risk and we define the insurer's target as follows:

$$CAP^{*}_{j,t} = a^{'} X^{C}_{j,t} + u^{C}_{j,t} \tag{5}$$

$$RISK^{*}_{j,t} = b^{'} X^{R}_{j,t} + u^{R}_{j,t} \tag{6}$$

where

$X^{C}_{j,t}$、 $X^{R}_{j,t}$ = vectors of explanatory variables,

a、 b = parameter vectors,

$u^{C}_{j,t}$、 $u^{R}_{j,t}$ = random disturbance terms.

Substituting Eq. (5) and (6) into Eq. (3) and (4) and rearranging them yields the following equation specifications:

$$\Delta CAP_{j,t} = \alpha a^{'} X^{C}_{j,t} + \alpha CAP_{j,t-1} + \alpha^{RV} RV_{j,t-1} + \nu^{C}_{j,t} \tag{7}$$

$$\Delta RISK_{j,t} = \gamma b^{'} X^{R}_{j,t} + \gamma RISK_{j,t-1} + \gamma^{RV} RV_{j,t-1} + \nu^{R}_{j,t} \tag{8}$$

where

$$\nu^{C}_{j,t} = \alpha u^{C}_{j,t} + \varepsilon^{C}_{j,t}$$
$$\nu^{R}_{j,t} = \gamma u^{R}_{j,t} + \varepsilon^{R}_{j,t}$$

In this paper, we refer to CS and use several variables to explain the changes of capital-to-asset ratio and risk. The model can be rewritten as follows:

$$\Delta CAP_{j,t} = \beta_0^C + \beta_{IV}^C IV_{j,t}^C + \beta_{RISK}^C \Delta RISK_{j,t} + \beta_{RV}^C RV_{j,t-1} + \alpha CAP_{j,t-1} + \nu_{j,t}^C \quad (9)$$

$$\Delta RISK_{j,t} = \beta_0^R + \beta_{IV}^R IV_{j,t}^R + \beta_{CAP}^R \Delta CAP_{j,t} + \beta_{RV}^R RV_{j,t-1} + \gamma RISK_{j,t-1} + \nu_{j,t}^R \quad (10)$$

where

β_0^C、 β_0^R = intercepts,

IV = instrumental variables,

$\nu_{j,t}^C$、 $\nu_{j,t}^R$ = the unexplained adjustments of Eq. (9) and Eq. (10).

We further follow BS and decompose the risk into asset and product risk. The model is rewritten as follows:

$$\begin{aligned}\Delta CAP_{j,t} &= \beta_0^C + \beta_{IV}^C IV_{j,t}^C + \beta_{AR}^C \Delta A\_RISK_{j,t} + \beta_{PR}^C \Delta P\_RISK_{j,t} \\ &\quad + \beta_{RV}^C RV_{j,t-1} + \alpha CAP_{j,t-1} + \nu_{j,t}^C\end{aligned} \quad (11)$$

$$\begin{aligned}\Delta A\_RISK_{j,t} &= \beta_0^{AR} + \beta_{IV}^{AR} IV_{j,t}^{AR} + \beta_{CAP}^{AR} \Delta CAP_{j,t} + \beta_{PR}^{AR} \Delta P\_RISK_{j,t} \\ &\quad + \beta_{RV}^{AR} RV_{j,t-1} + \gamma^{AR} A\_RISK_{j,t-1} + \nu_{j,t}^{AR}\end{aligned} \quad (12)$$

$$\begin{aligned}\Delta P\_RISK_{j,t} &= \beta_0^{PR} + \beta_{IV}^{PR} IV_{j,t}^R + \beta_{CAP}^{PR} \Delta CAP_{j,t} + \beta_{AR}^{PR} \Delta A\_RISK_{j,t} \\ &\quad + \beta_{RV}^{PR} RV_{j,t-1} + \gamma^{PR} P\_RISK_{j,t-1} + \nu_{j,t}^{PR}\end{aligned} \quad (13)$$

where

β_0^C、 β_0^{AR}、 β_0^{PR} = intercepts,

$\Delta A\_RISK_{j,t}$ = the change in the asset risk of firm j from time t-1 to t,

$\Delta P\_RISK_{j,t}$ = the change in the product risk of firm j from time t-1 to t,

$A\_RISK_{j,t-1}$ = the asset risk of firm j as time t-1,

$P\_RISK_{j,t-1}$ = the product risk of firm j's time t-1,

$v_{j,t}^{C}$, $v_{j,t}^{AR}$, $v_{j,t}^{PR}$ = the unexplained adjustments of Eq. (11), Eq. (12) and Eq. (13).

2.2 Definition of Variables

2.2.1 Decision Variables

The insurer can attain optimal solvency through the choice of two parameters, the capital-to-asset ratio and the level of risk.

- Capital-to-asset ratio

Capital-to-asset ratio (CAP) is defined as surplus divided by total admitted assets. Compared with CS, we simplify their measurement and ignore the GAAP adjustments[1]. CH_CAP denotes the change of capital ratio from the previous period to the current period and CAP_1 is the capital ratio in the last period.

- Risk

The classifications of risk are those used by BS and include both asset risk and product risk. The calculation of asset risk is the same as BS but the product risk is

[1] The adjustments are the reserves for unauthorized reinsurance and the excess of statutory reserves over statement reserves.

designed to be similar with asset risk that is different from BS.

- Total Risk

Total risk is the sum of the asset risk and product risk. CH_TOTALRISK denotes the change of total risk from the previous period to the current period and TOTALRISK_1 is the total risk in the last period. The methods used to calculate these are as follows:

- Asset risk

We measure this risk in a similar way to the Risk Based Capital System[2]. We divide total admitted assets into bonds, stocks, mortgages, real estate and cash & short-term investments. Each category is assigned a specific constant.

Bonds are ranked into six groups.

$$\begin{aligned} BOND = {} & class\_01*0.003+class\_02*0.001+class\_03*0.02 \\ & +class\_04*0.045+class\_05*0.1+class\_06*0.3 \end{aligned} \quad (14)$$

Stock assets are separated into preferred stock and common stock.

$$\begin{aligned} STOCK = {} & \left[\frac{PRE\_STOCK*(0.023+0.03+0.004+0.065+0.12+0.3)}{6}\right] \\ & +\left[\frac{COM\_STOCK*(0.003+0.150)}{2}\right] \end{aligned} \quad (15)$$

The constants of mortgages and real estate are 0.05 and 0.1 respectively. The

[2] 2000 NAIC Property and Casualty Risk-Based Capital Report Including Overview and Instructions for Companies.

product of cash & short-term investments is 0.0343 ((0.003+0.05+0.05)/3). This sum is then divided by total admitted assets to give us asset risk. CH_ASSETRISK denotes the change of asset risk from the previous period to the current period and ASSETRISK_1 is the asset risk in the last period.

$$ASSET\_RISK = \frac{\begin{array}{l} BOND + STOCK + total\_mortgages * 0.05 + total\_real\_estate * 0.343 \\ + cash \& short - term\_investment * 0.0343 \end{array}}{total\_admitted\_asset} \quad (16)$$

- Product risk

The calculation of product risk and asset risk is similar. We assign appropriate constants to different products. The numerator is divided into net written premiums and reserves, which are determined as follows:

Net Written Premiums =

homeowners & farm owners*0.917+ auto. liability*1.0295

+ workers' compensation* 1.008+ commercial multiple peril* 0.917

+ medical malpractice*1.4165+ special liability*0.917

+ other liability*1.082+ fidelity & surety*0.875

+ international*1.169+ reinsurance* 1.3015

+ products liability*1.095+ others*0.889 (17)

Reserve =

homeowners & farm owners*0.275+ auto. liability*0.2705

+ workers' compensation* 0.273 +commercial multiple peril* 0.374

+ medical malpractice*0.5275 + special liability*0.244

+ other liability*0.520 + fidelity & surety*0.269

+ international*0.327 + reinsurance* 0.5755

+ products liability*0.532 + others*0.160 (18)

The sum is divided by total admitted assets to give us an indicator of product risk. CH_PRODUCT_RISK denotes the change of product risk from the previous period to the current period and RPODUCT_RISK_1 is the product risk in the last period.

2.2.2 Instrumental variables

- Size

The sizes of insurers (LNASSET) are measured as the natural log of total admitted assets. Large firms have the benefit of more diversification, require less capital to attain a given solvency target and can bear higher risk levels.

- National Firm

This variable discriminates between those firms that operate nationally from those that operate locally. NATIONAL is equal to 1 if the insurer is licensed in over 16 states and is equal to zero for a regional firm. Because national firms have to underwrite and price a great diversity of policies, they require more discretion than those operating regionally. A higher level of managerial discretion increases the cost to policyholders; so national firms require higher capital.

- Licensed in New York

The dummy variable (NEWYORK) is equal to 1 if the firm is licensed in New York and otherwise is equal to zero. The regulatory system in New York emphasizes rigorous licensing regulations and the solvency of insurers. A financially weak firm licensed in New York will spend more on regulatory costs than others. NEWYORK, therefore, has a positive relationship with CAP and a negative relationship with risk.

- Independent agency firm

The dummy variable (AGENCY) represents insurers that have two major distribution channels to market their products. For independent agency firms[3], AGENCY is equal to 1; otherwise it is equal to zero. Because of the less insurer-specific human capital that independent agents employ, insurers with independent agency marketing systems can bear a higher level of insolvency risk than exclusive agency firms. The influence of this on an independent firm's behavior tends

[3] In the A.M.Best Key Rating Guide, the independent agency firms include A (Agency), AB (Agency, Broker), AD (Agency, Direct Response), B (Broker), BA (Broker, Agency), BD (Broker, Direct Response), BG (Broker, Managing, General Agent), G (Managing General Agent), GA (Managing General Agent, Agency), GB (Managing General Agent, Broker), GD (Managing General Agent, Direct Response), and L (General Agent).

to lower capital ratios and allow higher risk (Regan 1996).

- Unaffiliated single company

This variable is used to determine whether the firm belongs to an insurance group or not. An unaffiliated single company (SINGLE) is equal to 1 and is equal to zero otherwise. When facing financial difficulties, an unaffiliated single company can exercise the default option, and simply affects its own reputation. This can’t be done if the company is a member of a group since the group has to consider the adverse impact on the going reputation. We posit that this variable would have a negative relationship with CAP and a positive relationship with risk.

- Intra-group Herfindahl index

The intra-group Herfindahl index measures the net premiums written by the members of each insurance group. As with SINGLE, the variable (HERINDEX) is equal to 1 if the firm is an unaffiliated single company and equal to the intra-group Herfindahl index if the firm is a member of an insurance group. We expect the variable’s effect on capital ratio and risk to be the same as SINGLE.

- Organization

The main organizations of property-liability insurers are classified as stock, mutual and others. We use two dummy variables to express the type of an insurer. If the insurer is a stock company, STOCK is equal to 1; otherwise it is equal to zero. If the insurer is a mutual company, MUTUAL is equal to 1; otherwise it is equal to zero. The capital ratios of stock companies are expected to be lower than those of mutual companies because stock insurers have lower agency costs for managers and residual holders of the company. Stock insurers are expected to bear more risk than mutual insurers since the stockholders can diversify assumed risk in the stock market.

2.2.3 **Regulatory Variables**

- RBC Ratio

The RBC ratio is a key element in this paper. Regulatory pressure is mainly determined by the company's RBC ratio, which decides the regulator's action. There are two methods to estimate regulatory pressure. First, the variable (RBCRATIO_1) is the insurer's original RBC ratio from the previous year. In order to understand how this ratio affects the firm's capital and risk levels, we use a categorical measurement to capture the regulatory pressure in the insurance industry. The variables (lag_RBC_1-lag_RBC_10) indicate the n-tenth of the RBC ratio for the previous year.

2.2.4 **Other Variables**

- Year Variables

The influence of time is controlled by dummy variables. If the sample is in 1996, the DUMMY96 is equal to 1 and otherwise it is equal to zero. There are five dummy variables in this paper.