A Study on Risk-Shifting Behaviors under Different Deposit Insurance Systems for Taiwan’s Commercial Banks

Chuang-Chang Chang* and Wei-Ju Chen

Abstract

This paper examines the risk-shifting behaviors of Taiwan’s commercial banks before and after Taiwan government adopted a risk-based premium system. We use the model of Duan et al. (1992) to tie the incremental insurance subsidy received by a bank to investigate the changes on the banks’ risk-shifting behavior. Furthermore, to obtain reliable estimates for testing our hypotheses, we employ Merton (1977) model to estimate the deposit insurance premium and use the maximum likelihood estimation method proposed by Duan (1994) to estimate the market value of banks’ assets. Our results find that, under the flat-rate premium system, there is a negative relationship between leverage and asset risk for old commercial banks, while opposite results for the new commercial banks. After adopting the risk-based premium system, the effect of risk-restraining factors decreases. Additionally, our results also show that there exist successful risk-shifting behaviors for commercial banks in Taiwan under the flat-rate premium system, whereas the risk-shifting behaviors do not mitigate after the implementation of risk-based premium system.

Key words: the risk-shifting behavior; a risk-based premium system; deposit insurance premium; Maximum likelihood estimation

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1. Introduction

Financial stability and sound financial institution are important to the economic growth and the development of financial market for a country. To safeguard the benefits of depositors in financial institutions, to maintain an orderly credit system, and to enhance the sound development of financial operations, the Central Deposit Insurance Corporation (CDIC) of Taiwan was established on September 1985. The responsibilities of CDIC include handling deposit insurance, examining insured institutions, assisting problem insured institutions, and dealing with failed insured institutions. To follow the trend of financial liberalization and to give the financial institutions higher freedom, Taiwan government adopted a voluntary basis at the beginning of implementing a deposit insurance system. As a result, most of financial institutions were reluctant to participate in the system due to the burden of increasing deposit insurance assessment. In order to achieve the goal of maintaining the confidence of depositors and stabilizing the financial system, CDIC changed the deposit insurance system to a mandatory basis since February 1999.

At the debut of the Taiwan’s deposit insurance system, risk differential among financial institutions was not significant because of the more regulation forcing in the financial institutions, including setting up and business scopes, etc. Hence, CDIC adopted a flat-rate deposit insurance system in the early stage. The deposit insurance premium that the CDIC charged was five basis points from 1985 to 1986, four basis points in 1987, and one point five basis points in 1988 and the following years until 1999. We summarized the different premium charged by CDIC at different stages in Table 1.

[Insert Table 1 about here]
Several papers, such as Merton (1977) and Pesando (1985), showed that a flat-rate deposit insurance system would encourage banks to take excessive risk since premiums are not risk adjusted. Banks would like to transfer their risks to insurer when they encounter higher risk exposures than the risk category on which the flat-rate is based. Higher risk increases the value of the CDIC’s insurance services for banks. If the incremental cost that a bank should pay does not rise to absorb this value, increasing risk exposure extracts an incremental deposit insurance subsidy. Banks may benefit the subsidy from the insurer. Hence, the fairness of a flat-rate deposit insurance system was strongly unsupported.

Tremendous literatures also study the risk-shifting behaviors of financial institutions under the flat-rate premium deposit insurance system. Duan, Moreau and Sealey (1992) link the changes in deposit insurance premiums to the changes in banks’ risk exposure. They find that the restraints on bank’s risk-shifting dominate risk-taking incentives in the period between 1976 and 1986 for thirty U.S. commercial banks. For the period 1985-1994, Hovakimian and Kane (2000) find that capital regulation did not prevent U.S. banks from shifting risk to the FDIC. Aggressive banks could extract a deposit insurance subsidy from the insurer. While their results are different from those reported in Duan et al. (1992), they show that the divergence may be due to differences in the time periods covered.

The risk-based deposit insurance system was implemented in the United States since 1993. Due to the financial liberalization sped up in the past two decades, the differences of risk exposures between different financial institutions significantly enlarge in Taiwan. To reflect the status of commercial banks’ risk exposures, Taiwan government which is the first Asian country, decided to implement a risk-based premium scheme since July 1999. The scheme adopted “capital adequacy ratio of the insured institutions” and “aggregate scores of the examination data ranking of the
National Financial Early-Warning System” as risk indicators. The insured institutions were categorized in nine risk groups and a three-grade premium was applied to the nine risk groups. The deposit insurance rate is charged according to different levels of risk since July 1999. The rates are arranged among 1.5, 1.75, and 2 basis points of insured deposits, respectively. In order to build up sufficient deposit insurance pay-off special reserves and strengthen the ability of dealing with problem financial institutions, the rate of deposit insurance increase to 5, 5.5, and 6 basis points, respectively since 2000. Table 2 summarizes the latest premium rates for domestic banks, local branches of foreign banks', trust and investment companies, and credit cooperatives associations.

[Insert Table 2 about here]

The flat-rate deposit insurance system implemented by Taiwan’s CDIC was changed after July 1999. Therefore, the risk-shifting behavior of commercial banks may be different after the implementation of the risk-based premium system. In this paper, we try to examine the following issue: whether the risk-shifting behaviors of commercial banks in Taiwan change or not under different deposit insurance systems. To answer the above question, we test two interesting hypotheses in this paper: (i) A flat-rate deposit insurance system would encourage commercial banks to take excessive risk so that they can get subsidy from the insurer since premiums are not risk adjusted; (ii) The risk-based deposit insurance system would prevent commercial banks from taking risk exposures and hence could mitigate risk-shifting behaviors. Hence our study will provide evidences for whether the risk-shifting behaviors of commercial banks in Taiwan change or not before and after Taiwan government adopted risk-based deposit insurance system.

To fulfill the above mentioned two hypotheses, we adopt the Merton (1977) model to estimate deposit insurance premium. Furthermore, to implement Merton’s model,
the two unobservable variables – the bank asset value and the volatility parameter – have to be estimated. Ronn and Verma (1986) suggest using two restrictions for the identification of these two unknowns. However, their method has a major statistical problem. In this paper, we employ the maximum likelihood estimation method proposed by Duan (1994) to estimate the two unobservable variables. His approach is not only consistent with the theoretical model of Merton (1977), but also makes statistical inference as a straightforward task.

We use the maximum likelihood estimation method of Duan (1994) to estimate inputs of Merton’s model\(^2\). And similar to Duan et al. (1992), we examine risk-shifting behavior in Taiwan during the period between 1986 and 2004 for eleven commercial banks. Our main findings can be summarized as follows: (1) Under the flat-rate deposit insurance system, there is a negative relationship between leverage and asset risk for old commercial banks and the contrary for the new commercial banks. For the sake of competing with original old commercial banks, risk-restraining factors can’t prevent new commercial banks from taking more risk. After changing to the risk-based premium system, we can’t reject the hypothesis of a positive relationship for all banks of our sample. The effect of risk-restraining factors even decreases in this period. The risk-restraining power due to the introduced of the risk-based premium system can’t cancel out the incentive of taking risk causing by the financial liberalization and internationalization: (2) we find that there are successful risk-shifting behaviors regardless of the flat-rate system or the risk-based premium system. The CDIC introduced the risk-based premium system and attempted to decrease the banks’ incentive of shifting risk. But the difference of each grade of

\(^2\) We also use the method of Ronn and Verma (1986) to estimate fair FDIC premiums and then examine risk-shifting behavior. We got different results comparing with the test result of MLE method. Because the statistical problem of Ronn and Verma (1986) method, we only analyze the results of MLE method and show the test result of Ronn and Verma (1986) method in the appendix of this paper.
premium is only 0.25 or 0.5 basis points. It seems that the small premium difference can’t prevent bank managers from shifting their commercial banks’ risks to the CDIC.

The remainder of the paper is organized as follows: Section 2 presents the theoretical model and estimation method employed to estimate risk-based deposit insurance premiums for individual banks. Section 3 describes the test model and the hypotheses to test for risk-shifting behavior. Our sample and results are discussed in section 4. Section 5 concludes the paper.

2. The theoretical model and estimation method

2.1. The Theoretical Model

In this paper, we employ Merton’s put option pricing model of deposit insurance to estimate insurance premium of a commercial bank. As derived in Merton (1977), the value of deposit insurance premium per dollar of insured deposits at time t, \( I_t \), can be expressed as follows:

\[
I_t(V_t, \sigma_v) = N\left(\sigma_v\sqrt{T-t} - d_i\right) - \frac{V_t}{D} N\left(-d_i\right)
\]

(1)

where

\[
d_i = \frac{\ln \left(\frac{V_t}{D} \frac{\sigma_v^2(T-t)}{2}\right)}{\sigma_v\sqrt{T-t}}
\]

(2)

\( D \) : the total amount of deposits;
\( V_t \) : the asset value of the bank at time t;
\( \sigma_v \) : the instantaneous standard deviation of the return on \( V \);
\( N(.) \) : the cumulative standard normal distribution;
\( T \) : the expiration date of the deposit insurance contract;

2.2. The Estimation Method

According to Merton’s model, the bank asset value and the volatility parameter are
unobservable and have to be estimated. By interpreting the banker’s equity as a call option on the bank’s assets, we can obtain the relationship expressed in equation (3). From the first derivative of the equation (3), we can get the relationship between the equity and asset volatility as equation (4). Ronn and Verma (1986) suggest using these two equations to solve the two unknown parameters.

\[ E_t = V_tN(d_1) - D(N(d_1 - \sigma_v\sqrt{T-t})) \] (3)

\[ \sigma_E = \frac{V_tN(d_1)}{E_t}\sigma_v \] (4)

As pointed out by Duan (1994), the Ronn and Verma (1986) method has a serious statistical problem. Since the volatility relationship expressed in equation (4) is directly derived from the first derivative of the value equation given in equation (3), it does not provide an additional restriction for identification. On the other hand, the solution is incorrectly obtained by setting the equity volatility to be a constant. However, the volatility of equity must be stochastic which can be directly referred from the theoretical model and hence, the sample variance cannot be used as an estimate for equity volatility. As a result, Ronn and Verma method does not meet the usual statistical properties such as consistency and efficiency.

In this paper, we use Duan’s (1994) maximum likelihood estimation method to estimate \( V \) and \( \sigma_v \). According to Duan (1994), these estimators are consistent and asymptotically efficient. This approach is also consistent with the theoretical model of Merton (1997). Besides, the asymptotic distribution makes it possible to make straightforward statistical inference. Duan’s (1994, 2000) maximum likelihood estimation method is briefly described as follows. The bank asset value, \( V_t \), is assumed to follow a lognormal process. That is,

\[ d\ln V_t = u dt + \sigma_v dW_t \] (5)
where $W_t$ is a Wiener process. The one-period transition density of the model is characterized by following equation.

$$\ln \frac{V_{t+1}}{V_t} \sim N(u, \sigma_v^2)$$

(6)

where $N(u, \sigma_v^2)$ denotes a normal distribution with mean $u$ and variance $\sigma_v^2$.

Using the assumption of normality, the log-likelihood function for a sample of unobserved $V_t$, $t=1,\ldots,n$ can be derived as follows:

$$L_v(V_t, t = 1,\ldots,n; \mu, \sigma_v)$$

$$= -\frac{n-1}{2} \ln(2\pi) - \frac{n-1}{2} \ln \sigma_v^2 - \sum_{i=2}^{n} \ln V_i - \frac{1}{2\sigma_v^2} \sum_{i=2}^{n} \left[ \ln \left( \frac{V_i}{V_{i-1}} \right) - \mu \right]^2$$

(7)

Equation (7) defines an element-by-element transformation from the unobserved sample of asset values to the observed sample of equity values. Since this data transformation is on an element-by-element basis, we can apply the transformed data method to obtain the log-likelihood function for the observed sample of equity values. According to Duan (2000), the log-likelihood function for the equity values can be written as follows:

$$L_v(E_t, t = 1,\ldots,n; \mu, \sigma_v) = -\frac{n-1}{2} \ln(2\pi) - \frac{n-1}{2} \ln \sigma_v^2 - \sum_{i=2}^{n} \ln \hat{V}_i(\sigma_v) - \frac{1}{2\sigma_v^2} \sum_{i=2}^{n} \left[ \ln \left( \frac{\hat{V}_i(\sigma_v)}{\hat{V}_{i-1}(\sigma_v)} \right) - \mu \right]^2$$

(8)

where the asset value estimate, $\hat{V}_i(\sigma_v)$, is the unique solution to equation (3) for a given $\sigma_v$, and $\hat{d}_t$ is computed using this estimated asset value $\hat{V}_i(\sigma_v)$.

We use the above log-likelihood function to obtain the maximum likelihood estimates of asset volatility and implied asset value. And then the two estimators can be used in equation (1) to calculate deposit insurance premium.
3. Methodology and Testing Hypothesis

According to equation (1), a manager can increase the value of the deposit insurance subsidy by increasing asset risk $\sigma_v$ and/or leverage $D/V$. If the manipulation of $\sigma_v$ and $D/V$ cause the increase of the risk-adjusted insurance premium, banks are successful to shift risk to the insurer. Duan et al (1992) translate this implication into two testable hypotheses by approximating the change in the per-dollar insurance premium, with respect to asset risk, as follows:

$$\Delta I \equiv \frac{\partial I}{\partial \sigma_v} \Delta \sigma_v + \frac{\partial I}{\partial (D/V)} \frac{\partial (D/V)}{\partial \sigma_v} \Delta \sigma_v \quad (9)$$

Equation (9) is rewritten as:

$$\Delta I \equiv \beta_1 \Delta \sigma_v \quad (10)$$

where

$$\beta_1 \equiv \frac{\partial I}{\partial \sigma_v} + \frac{\partial I}{\partial (D/V)} \alpha_1 \quad (11)$$

$$\alpha_1 \equiv \frac{d(D/V)}{d\sigma_v} \quad (12)$$

We describe the two hypotheses about the character of risk-shifting as follows:

**Hypothesis 1: There is a positive relationship between leverage and asset risk**

$(a_i \geq 0)$.  

Hypothesis 1 tests if there is a negative relationship between leverage and asset risk. A flat-rate system encourages banks to take excessive risk so that they can get subsidy form the insurer since premiums are not risk adjusted. However, several factors can restrain excessive risk taking by banks. If there are some risk-restraining factors, the relation between $\sigma_v$ and $D/V$ will be negative, and the $\alpha_i$ will be negative. Rejection of Hypothesis 1 suggests that leverage risk and asset risk are negatively
linked by banks’ own decision making, regulatory policy, etc. But it is not sufficient to conclude that risk-shifting does not happen.

The risk-restraining factors, excluding the insurance scheme, mentioned by the literatures including: (1) Regulatory discipline: Bank regulations, such as capital requirement, asset monitoring and seizure closure rules, and other corrective actions can prevent risk-shifting and accompanying wealth transfers. Flannery (1982, 1989) argues that existing regulatory practice, by linking capital adequacy to loan quality, can potentially eliminate risk-shifting. Keeley and Furlong (1990) find that banks take less risk when capital requirements increase. (2) Market discipline: Ellis and Flannery (1992) and Flannery and Sorescu (1996) show uninsured depositors require commensurately higher yields for their deposits from riskier banks. (3) Self-discipline through charter value: closed banks will lose their valuable charters. Keeley (1990) and Marcus (1984) indicate that in order to retain this intangible asset, bank managers tend to take less risk. (4) Managerial risk-aversion: banks managers’ risk aversion can prevent them from taking excessive risk. Given their specific human capital, they have more to lose if their banks are closed. Saunders et al. (1990) develop evidence of a relation between ownership structure and risk taking. In this paper, we take another angle to investigate how the changes on deposit insurance system affect the risk-shifting behavior of commercial banks in Taiwan. We compare $a_l$ before and after the implementation of the risk-based deposit insurance rate system to see whether the risk-based premium can mitigate risk-taking incentive or not.

**Hypothesis 2:** The increase of asset volatility would not result in the increase of the deposit insurance premium of commercial banks ($\beta_1 \leq 0$).

Hypothesis 2 tests whether there is a successful risk-shifting in individual banks. If Hypothesis 2 is rejected, then it suggests that there exists risk-shifting behavior. A positive $\beta_1$ indicate the increase of asset volatility would result in the increase of the
deposit insurance premium. The commercial banks are successful in increasing their deposit insurance subsidy through risk-shifting during the sample period. Merton (1977) shows that – absent market and government disciplinary responses – the partial derivatives $\partial I/\partial \sigma_v$ and $\partial I/\partial (D/V)$ are positive. If $\sigma_v$ and $D/V$ are not negatively linked (positive $\alpha_1$), then one would expect to find that there exists risk-shifting behavior. In other words, $\beta_1$ should be significantly positive. That is to say, if there are no risk-restraining factors in banks, the increase of assets volatility must cause the increase of the insurance premium. On the other hand, if risk-sensitive capital regulation and other risk-restraining factors introduce negative linkages between $\sigma_v$ and $D/V$ (negative $\alpha_1$), the net effect of how disciplinary restraints modify risk-shifting incentives would depend on the degree of the restraints. From equation (11), if the magnitude of $\frac{\partial I}{\partial (D/V)} \alpha_1$ is negative and larger than that of $\frac{\partial I}{\partial \sigma_v}$, we can get a negative $\beta_1$. Otherwise, $\beta_1$ could be still positive. This implies that, if we want to conclude that there is no risk-shifting behavior in banks, the influence of risk-restraining factors ($\alpha_1$) must be large enough to cancel out the risk-shifting incentive.

Empirically, we test hypotheses 1 and 2 for an individual bank $j$ by estimating the following two equations in the first period (July 1, 1999 to December 31, 2001) data which is collected under flat-rate deposit insurance system.

$$
\frac{D_{jt}}{V_{jt}} = \alpha_0 + \alpha_1 \sigma_{V_{jt}} + \varepsilon_{jt} \tag{13}
$$

$$
I_{jt} = \beta_0 + \beta_1 \sigma_{V_{jt}} + \xi_{jt} \tag{14}
$$

In the second period (January 1, 2002 to September 30, 2004) data which is collected under risk-based deposit insurance system, there is an important event in the Taiwan financial market. Holding Companies Law took effect on November, 2001. After then,
many financial institutions merge and become financial holding companies. This event changed the competitive environment and the behavior of taking risk between commercial banks. Since such a change may affect the relationship between $\sigma_y$ with $D/V$ and $\sigma_y$ with $I$. We include a dummy variable, Dholding, in the regression to account for the influence of the structural change in our second sample period. The value of Dholding is set to 0 for the sample period July 1, 1999 to December 31, 2001, and is set to 1 for the sample period January 1, 2002 to September 30, 2004. The specifications are described as follows:

$$\frac{D_{jt}}{V_{jt}} = \alpha_{0j} + \alpha_{1j}\sigma_{y_{jt}} + \alpha_{2j}\text{Dholding}_{jt} + \varepsilon_{jt}$$ \hspace{1cm} (15)

$$I_{jt} = \beta_{0j} + \beta_{1j}\sigma_{y_{jt}} + \beta_{2j}\text{Dholding}_{jt} + \xi_{jt}$$ \hspace{1cm} (16)

4. The results of testing risk-shifting hypotheses

4.1. Data and Variables

The model derived in the previous section is estimated with quarterly data in the period between the first quarter of 1986 and the third quarter of 2004. Equation (13) and equation (14) are both estimated for $t \in [1986.01.01, 1999.06.30]$. Equation (15) and equation (16) are both estimated for $t \in [1999.07.01, 2004.09.30]$. Our analysis focuses on Taiwan’s commercial banks. We require data on both balance sheet items and market variables to estimate the risk-based deposit insurance premiums for individual banks. The sample banks are supposed to be listed in the Taiwan Stock Exchange (TSE) in order to get the daily data for equity market prices of commercial banks. Moreover, we delete some commercial banks, which have no trading data before September 2004, such as delisting, being merged and becoming a member of financing holding companies. Finally, we have eleven banks in our sample.
Six of eleven commercial banks are old commercial banks, including Chang Haw Bank, Hsinchu International BANK, International Bank of Taipei, Tainan Business Bank, Taitung Business Bank and Taichung Commercial Bank. The others are new banks, including The Chinese Bank, Cosmos Bank of Taiwan, Union Bank of Taiwan, Far Eastern International Bank and Ta Chong Bank. When we use Duan’s (1994, 2000) maximum likelihood estimating method to estimate $V$ and $\sigma_y$, we require to input two category variables—a bank’s quarterly total debt and its daily market value of equity. For this study, the daily market value and the quarterly debt data are retrieved from Taiwan Economic Journal (TEJ) Database.

4.2. Empirical Results

B.1 Testing Hypothesis 1

To test hypothesis 1, we use equations (13) and (15) to estimate the coefficients separately for each of eleven commercial banks. For comparing the risk-shifting behavior of commercial banks in the two sub-periods, we estimate and test the coefficients of equation (13) in the first sub-period and equation (15) in the second sub-period for each commercial bank. The regressions include corrections for forth-order autocorrelation in residuals if tests indicate significant autocorrelation of the error terms. The results of the first period are reported in Table 3. The coefficients of $\alpha_1$ for old commercial banks are negative. We can reject hypothesis 1 for five of six commercial banks. On the contrary, all the coefficients of $\alpha_1$ for new commercial banks are positive. We can’t reject hypothesis one for five new commercial banks. From the different results of new commercial banks and old commercial banks, we find that the effect of the restraint factors is stronger in old commercial banks than in those of new commercial banks. This result is may be due to that, to compete with the original old commercial banks, new commercial banks have to take more risk. The
incentive of taking risk dominates the restraint factors. Equation (13) is also estimated by pooling the time-series and cross-sectional data. The pooling results are shown in the bottom line of Table 3. The coefficient of $\alpha_1$ is negative and we can eject hypothesis 1 at the 1% significant level. Overall, the evidence indicates that risk-restraining factors mitigate risk-taking incentives of banks in our first period.

Table 4 presents the results of the second period. The coefficients of $\alpha_1$ are all positive. We can’t reject hypothesis 1 for all eleven commercial banks and the pooling result. When Taiwan government changed the deposit insurance system (from flat-rate to risk-based), the incentives of risk-taking for commercial banks increase. It means that risk-based deposit insurance has no effect in restraining risk-shifting behavior for commercial banks in Taiwan. The risk-based deposit insurance system is adopted under the background of financial liberalization and internationalization. The financial liberalization decreases regulatory discipline, such as the open of business scopes, and increases the ability of commercial banks for taking more risk. The financial internationalization enhances the competitiveness between internal banks with international banks. To improve competitiveness, internal banks may be enforced to become riskier. As a result, although CDID shifts the flat-rate deposit insurance system to risk-based deposit insurance system, it is not ensured that the incentive of taking risk for commercial banks can be eliminated. Our estimated results of the regressions indicate that the incentive of taking risk exceeds the restraining factors result from the risk-based deposit insurance system. The reason for the ineffective of shifting to the risk-based deposit insurance system may be due to the difference of each grade of premium is too small. From Table 1, the difference on deposit insurance premium is 0.25 and 0.5 basis point for each grade respectively for the beginning period of implementation and after the reversion of January 1, 2000. The small
difference on deposit insurance premium between different grades would result in the weak incentive to be a better grade. On the other hand, we include a dummy variable, Dholding, on the regression to account for the influence of the setting up of financial holding company in this period. The coefficients of $\alpha_2$ are negative for most of banks and only significantly negative at two banks, Hsinchu International Bank and Cosmos Bank, Taiwan. The results indicate, after the setting up of the financial holding companies, the leverage of non-holding banks decrease. This can be explained by the decrease of deposits in non-holding banks after the competing of financial holding company.

[Insert Table 4 about here]

B.2 Testing Hypothesis 2

We test hypothesis 2 for the eleven commercial banks by estimating equations (14) and (16). Like testing hypothesis 1, to test hypothesis 2, we also divide the sample period into two sub periods: one is from January 1, 1986 to June 30, 1999 and the other is from July 1, 1999 to September 30, 2004. We attempt to account for the effect of change in the deposit insurance premium rate in 1999. Table 5 shows the result for the first period. The coefficients of $\beta_1$ for all commercial banks are significantly positive. Hypothesis 2 can be rejected for all eleven banks at the 1% significance level. These results suggest that all commercial banks in the first sample period have been successful in shifting risk. Although old commercial banks have been restrained excess risk taking from the test results of hypothesis 1, the risk-taking incentives dominate the restrains on bank risk-shifting. Finally, equation (14) is estimated with pooled cross-sectional and time-series data, and the estimates are shown at the bottom of Table 5. These estimates also show significantly positive relationship between the insurance premium per dollar of insured deposits (I) and the instantaneous standard deviation of the return on asset value ($\sigma_v$).
The results for testing hypothesis 2 for the second period are presented in Table 6. Similar to the first period data, the coefficients of \( \beta_1 \) for all commercial banks are significantly positive. Moreover, the coefficient, \( \beta_1 \), of pooled regression for all commercial banks is also significantly positive. The above results of testing hypothesis 1 show that banks do not decrease leverage risk when assets risk rises in the second sample period. Considering together with the results of testing hypothesis 1 indicate that the change from flat-rate deposit insurance system to risk based deposit insurance system does not totally eliminate the banks’ risk-shifting behaviors. Furthermore, by comparing Table 5 with Table 6, we can find the coefficients of \( \beta_1 \) increase for all commercial banks and the pooled regression in the second sample period. No evidence shows that the degree of risk-shifting mitigates after changing the deposit insurance system (from flat-rate to risk-based rate). The result implies that risk based deposit insurance system does not restrain the risk-shifting behavior. Maybe larger difference on deposit insurance premium for different grade banks or more risk-restraining factors are necessary to offset the risk-shifting incentives of commercial banks. Furthermore, the \( \beta_2 \) coefficients for most banks are negatively and are significant for four of eleven banks. The general decrease in leverage after the introduction of financial holding companies would cause the decrease of the insurance premium.

4. Conclusions

This paper examines the risk-shifting behaviors of Taiwan’s commercial banks before and after Taiwan government adopted a risk-based premium system. We use the model of Duan et al. (1992) to tie the incremental insurance subsidy received by a
bank to investigate the changes on the banks’ risk-shifting behavior. Furthermore, to obtain reliable estimates for testing our hypotheses, we employ Merton (1977) model to estimate the deposit insurance premium and use the maximum likelihood estimation method proposed by Duan (1994) to estimate the market value of banks’ assets.

We try to examine the following issue: whether the risk-shifting behaviors of commercial banks in Taiwan change or not under different deposit insurance systems. To answer the above question, we test two interesting hypotheses in this paper: (i) A flat-rate deposit insurance system would encourage commercial banks to take excessive risk so that they can get subsidy from the insurer since premiums are not risk adjusted; (ii) The risk-based deposit insurance system would prevent commercial banks from taking risk exposures and hence could mitigate risk-shifting behaviors. Hence our study will provide evidences for whether the risk-shifting behaviors of commercial banks in Taiwan change or not before and after Taiwan government adopted risk-based deposit insurance system.

Our main findings can be summarized as follows: (1) Under the flat-rate deposit insurance system, there is a negative relationship between leverage and asset risk for old commercial banks and the contrary for the new commercial banks. For the sake of competing with original old commercial banks, risk-restraining factors can’t prevent new commercial banks from taking more risk. After changing to the risk-based premium system, we can’t reject the hypothesis of a positive relationship for all banks of our sample. The effect of risk-restraining factors even decreases in this period. The risk-restraining power due to the introduced of the risk-based premium system can’t cancel out the incentive of taking risk causing by the financial liberalization and internationalization: (2) we find that there are successful risk-shifting behaviors regardless of the flat-rate system or the risk-based premium system. The CDIC
introduced the risk-based premium system and attempted to decrease the banks’ incentive of shifting risk. But the difference of each grade of premium is only 0.25 or 0.5 basis points. It seems that the small premium difference can’t prevent bank managers from shifting their commercial banks’ risks to the CDIC.
Table 1: The Development of Deposit Insurance System in Taiwan

<table>
<thead>
<tr>
<th>Time</th>
<th>Participation Terms</th>
<th>Rate System</th>
<th>Insurance Premium</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985/09</td>
<td>Voluntary</td>
<td>Fixed rate</td>
<td>0.0500%</td>
</tr>
<tr>
<td>1987/07</td>
<td>Voluntary</td>
<td>Fixed rate</td>
<td>0.0400%</td>
</tr>
<tr>
<td>1988/01</td>
<td>Voluntary</td>
<td>Fixed rate</td>
<td>0.0150%</td>
</tr>
<tr>
<td>1999/01</td>
<td>Mandatory</td>
<td>Fixed rate</td>
<td>0.0150%</td>
</tr>
<tr>
<td>1999/07</td>
<td>Mandatory</td>
<td>Risk-based rate</td>
<td>0.0150%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(9 grades/3 levels)</td>
<td>0.0175%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.0200%</td>
</tr>
<tr>
<td>2000/01</td>
<td>Mandatory</td>
<td>Risk-based rate</td>
<td>0.0500%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(9 grades/3 levels)</td>
<td>0.0550%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.0600%</td>
</tr>
</tbody>
</table>

Data source: CDIC

Table 2: The Latest Deposit Insurance Premium for Domestic Banks, Local Branches of Foreign Banks', Trust and Investment Companies, and Credit Cooperatives Associations

<table>
<thead>
<tr>
<th>Composite Score of the Examination</th>
<th>A grade</th>
<th>B grade</th>
<th>C grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Adequacy Ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well Capitalized</td>
<td>0.050%</td>
<td>0.050%</td>
<td>0.055%</td>
</tr>
<tr>
<td>Adequately Capitalized</td>
<td>0.050%</td>
<td>0.055%</td>
<td>0.060%</td>
</tr>
<tr>
<td>Undercapitalized</td>
<td>0.055%</td>
<td>0.060%</td>
<td>0.060%</td>
</tr>
</tbody>
</table>

Data source: CDIC
Table 3: The Results of Testing Hypothesis 1 (Data Period: 1986/01-1999/06/30)

\[ \frac{D^j_{jt}}{V^j_{jt}} = \alpha_0 + \alpha_1 \sigma_{\nu_j} + \epsilon_{jt} \]

<table>
<thead>
<tr>
<th>Company name</th>
<th>Intercept</th>
<th>SIGMA_V</th>
<th>t</th>
<th>R^2</th>
<th>Sample period</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chang Haw Bank</td>
<td>0.841***</td>
<td>(0.3156)</td>
<td>(1.89)</td>
<td>0.524</td>
<td>1990/04-1999/06/30</td>
<td>37</td>
</tr>
<tr>
<td>Hsinchu International Bank</td>
<td>0.800***</td>
<td>(0.1960)</td>
<td>(1.00)</td>
<td>0.551</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>International Bank of Taipei</td>
<td>0.805***</td>
<td>(0.8305)</td>
<td>(4.00)</td>
<td>0.715</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>Tainan Business Bank</td>
<td>0.828***</td>
<td>(0.5726)</td>
<td>(2.71)</td>
<td>0.592</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>Taitung Business Bank</td>
<td>0.656***</td>
<td>(0.3215)</td>
<td>(1.98)</td>
<td>0.737</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>Taichung Commercial Bank</td>
<td>0.825***</td>
<td>(0.4471)</td>
<td>(1.76)</td>
<td>0.569</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>The Chinese Bank</td>
<td>0.841***</td>
<td>0.3188</td>
<td>3.78</td>
<td>0.693</td>
<td>1996/01-1999/06/30</td>
<td>14</td>
</tr>
<tr>
<td>Cosmos Bank, Taiwan</td>
<td>0.838***</td>
<td>0.3663</td>
<td>4.30</td>
<td>0.815</td>
<td>1995/10-1999/06/30</td>
<td>15</td>
</tr>
<tr>
<td>Union Bank of Taiwan</td>
<td>0.845***</td>
<td>0.1006</td>
<td>0.71</td>
<td>0.775</td>
<td>1995/10-1999/06/30</td>
<td>15</td>
</tr>
<tr>
<td>Far Eastern International Bank</td>
<td>0.818***</td>
<td>0.3876</td>
<td>5.01</td>
<td>0.727</td>
<td>1996/01-1999/06/30</td>
<td>14</td>
</tr>
<tr>
<td>Ta Chong Bank</td>
<td>0.884***</td>
<td>0.0710</td>
<td>0.47</td>
<td>0.641</td>
<td>1996/04-1999/06/30</td>
<td>13</td>
</tr>
<tr>
<td>Pooled Regression</td>
<td>0.795***</td>
<td>(0.2869)</td>
<td>(5.38)</td>
<td>0.072</td>
<td></td>
<td>378</td>
</tr>
</tbody>
</table>

* Significant at a level of 0.1; ** Significant at a level of 0.05; *** Significant at a level of 0.01.

Table 4: The Results of Testing Hypothesis 1 (Data Period: 1999/07/01-2004/09/30)

\[ \frac{D^j_{jt}}{V^j_{jt}} = \alpha_0 + \alpha_1 \sigma_{\nu_j} + \alpha_2 D_{holding_{jt}} + \epsilon_{jt} \]

<table>
<thead>
<tr>
<th>Company name</th>
<th>Intercept</th>
<th>SIGMA_V</th>
<th>t</th>
<th>Holding</th>
<th>t</th>
<th>R^2</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chang Haw Bank</td>
<td>0.918***</td>
<td>0.6811</td>
<td>7.83</td>
<td>0.0001</td>
<td>(0.01)</td>
<td>0.783</td>
<td>21</td>
</tr>
<tr>
<td>Hsinchu International Bank</td>
<td>0.926***</td>
<td>0.7094</td>
<td>13.60</td>
<td>0.0270</td>
<td>(2.06)</td>
<td>0.923</td>
<td>21</td>
</tr>
<tr>
<td>International Bank of Taipei</td>
<td>0.897***</td>
<td>0.2364</td>
<td>1.94</td>
<td>0.0020</td>
<td>(0.12)</td>
<td>0.583</td>
<td>21</td>
</tr>
<tr>
<td>Tainan Business Bank</td>
<td>0.943***</td>
<td>0.6261</td>
<td>7.11</td>
<td>0.0149</td>
<td>(1.25)</td>
<td>0.799</td>
<td>21</td>
</tr>
<tr>
<td>Taitung Business Bank</td>
<td>0.897***</td>
<td>1.3741</td>
<td>5.91</td>
<td>0.0569</td>
<td>1.70</td>
<td>0.740</td>
<td>21</td>
</tr>
<tr>
<td>Taichung Commercial Bank</td>
<td>0.940***</td>
<td>0.6002</td>
<td>5.83</td>
<td>0.0192</td>
<td>(1.39)</td>
<td>0.779</td>
<td>21</td>
</tr>
<tr>
<td>The Chinese Bank</td>
<td>0.919***</td>
<td>0.7122</td>
<td>18.78</td>
<td>0.0073</td>
<td>0.70</td>
<td>0.892</td>
<td>21</td>
</tr>
<tr>
<td>Cosmos Bank, Taiwan</td>
<td>0.894***</td>
<td>0.6068</td>
<td>4.72</td>
<td>0.0712</td>
<td>(4.73)</td>
<td>0.631</td>
<td>21</td>
</tr>
<tr>
<td>Union Bank of Taiwan</td>
<td>0.930***</td>
<td>0.3390</td>
<td>6.16</td>
<td>0.0108</td>
<td>(1.66)</td>
<td>0.739</td>
<td>21</td>
</tr>
<tr>
<td>Far Eastern International Bank</td>
<td>0.870***</td>
<td>0.7049</td>
<td>0.83</td>
<td>0.0391</td>
<td>(1.16)</td>
<td>0.831</td>
<td>21</td>
</tr>
<tr>
<td>Ta Chong Bank</td>
<td>0.915***</td>
<td>0.9539</td>
<td>19.91</td>
<td>0.0009</td>
<td>(0.06)</td>
<td>0.960</td>
<td>21</td>
</tr>
<tr>
<td>Pooled Regression</td>
<td>0.911***</td>
<td>0.7879</td>
<td>21.87</td>
<td>0.0097</td>
<td>(0.98)</td>
<td>0.678</td>
<td>231</td>
</tr>
</tbody>
</table>

* Significant at a level of 0.1; ** Significant at a level of 0.05; *** Significant at a level of 0.01.

Note: sample periods for all banks are 1999/07/01-2004/09/30.
Table 5: The Results of Testing Hypothesis 2 (Data Period: 1986/01/01-1999/06/30)

\[ I_{jt} = \beta_{0j} + \beta_{1j} \sigma_{Yt} + \beta_{2j} \sigma_{\text{holding}} + \xi_{jt} \]

<table>
<thead>
<tr>
<th>Company name</th>
<th>Intercept</th>
<th>SIGMA_V</th>
<th>t</th>
<th>(R^2)</th>
<th>Sample period</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chang Haw Bank</td>
<td>(0.005)***</td>
<td>0.0733***</td>
<td>7.27</td>
<td>0.602</td>
<td>1990/04-1999/06/30</td>
<td>37</td>
</tr>
<tr>
<td>Hsinchu International Bank</td>
<td>(0.012)***</td>
<td>0.1364***</td>
<td>5.26</td>
<td>0.348</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>International Bank of Taipei</td>
<td>(0.006)***</td>
<td>0.0516***</td>
<td>4.72</td>
<td>0.300</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>Tainan Business Bank</td>
<td>(0.008)**</td>
<td>0.0919***</td>
<td>4.98</td>
<td>0.323</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>Taitung Business Bank</td>
<td>(0.024)***</td>
<td>0.1328***</td>
<td>5.25</td>
<td>0.346</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>Taichung Commercial Bank</td>
<td>(0.006)*</td>
<td>0.0821***</td>
<td>3.31</td>
<td>0.240</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>The Chinese Bank</td>
<td>(0.021)**</td>
<td>0.3621***</td>
<td>9.63</td>
<td>0.885</td>
<td>1995/10-1999/06/30</td>
<td>14</td>
</tr>
<tr>
<td>Cosmos Bank, Taiwan</td>
<td>(0.030)**</td>
<td>0.4224***</td>
<td>9.15</td>
<td>0.866</td>
<td>1995/10-1999/06/30</td>
<td>15</td>
</tr>
<tr>
<td>Union Bank of Taiwan</td>
<td>(0.012)**</td>
<td>0.1868***</td>
<td>4.21</td>
<td>0.577</td>
<td>1995/10-1999/06/30</td>
<td>15</td>
</tr>
<tr>
<td>Far Eastern International Bank</td>
<td>(0.034)***</td>
<td>0.4083***</td>
<td>8.21</td>
<td>0.849</td>
<td>1996/01-1999/06/30</td>
<td>21</td>
</tr>
<tr>
<td>Ta Chong Bank</td>
<td>(0.017)*</td>
<td>0.2719***</td>
<td>5.72</td>
<td>0.779</td>
<td>1996/04-1999/06/30</td>
<td>13</td>
</tr>
<tr>
<td>Pooled Regression</td>
<td>(0.021)***</td>
<td>0.2026***</td>
<td>17.96</td>
<td>0.462</td>
<td></td>
<td>378</td>
</tr>
</tbody>
</table>

* Significant at a level of 0.1; ** Significant at a level of 0.05; *** Significant at a level of 0.01.

Table 6: The Results of Testing Hypothesis 2 (Data Period: 1999/07/01-2004/09/30)

\[ I_{jt} = \beta_{0j} + \beta_{1j} \sigma_{Yt} + \beta_{2j} \sigma_{\text{holding}} + \xi_{jt} \]

<table>
<thead>
<tr>
<th>Company name</th>
<th>Intercept</th>
<th>SIGMA_V</th>
<th>t</th>
<th>Holding</th>
<th>t</th>
<th>(R^2)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chang Haw Bank</td>
<td>(0.026)***</td>
<td>0.6354***</td>
<td>15.20</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.917</td>
<td>21</td>
</tr>
<tr>
<td>Hsinchu International Bank</td>
<td>(0.016)***</td>
<td>0.6694***</td>
<td>22.64</td>
<td>(0.0108)*** (2.4800)</td>
<td>0.966</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>International Bank of Taipei</td>
<td>(0.014)***</td>
<td>0.2993***</td>
<td>8.52</td>
<td>0.0004</td>
<td>0.1100</td>
<td>0.839</td>
<td>21</td>
</tr>
<tr>
<td>Tainan Business Bank</td>
<td>(0.015)***</td>
<td>0.6348***</td>
<td>14.71</td>
<td>(0.0039)*** (1.5600)</td>
<td>0.929</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Taitung Business Bank</td>
<td>(0.054)**</td>
<td>1.0116***</td>
<td>9.46</td>
<td>0.0256</td>
<td>2.1100</td>
<td>0.866</td>
<td>21</td>
</tr>
<tr>
<td>Taichung Commercial Bank</td>
<td>(0.013)**</td>
<td>0.5999***</td>
<td>13.30</td>
<td>(0.0096)*** (1.6900)</td>
<td>0.927</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>The Chinese Bank</td>
<td>(0.022)***</td>
<td>0.6341***</td>
<td>19.60</td>
<td>0.0010</td>
<td>0.1700</td>
<td>0.959</td>
<td>21</td>
</tr>
<tr>
<td>Cosmos Bank, Taiwan</td>
<td>(0.016)*</td>
<td>0.5292***</td>
<td>6.81</td>
<td>(0.0166)*** (2.2500)</td>
<td>0.734</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Union Bank of Taiwan</td>
<td>(0.016)***</td>
<td>0.4954***</td>
<td>19.13</td>
<td>(0.0058)* (1.9200)</td>
<td>0.962</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Far Eastern International Bank</td>
<td>(0.029)**</td>
<td>0.6455***</td>
<td>13.89</td>
<td>(0.0191)* (1.9900)</td>
<td>0.920</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Ta Chong Bank</td>
<td>(0.032)***</td>
<td>0.7855***</td>
<td>30.96</td>
<td>(0.0005)*** (0.0700)</td>
<td>0.984</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Pooled Regression</td>
<td>(0.026)***</td>
<td>0.6777***</td>
<td>39.43</td>
<td>(0.0025)*** (0.7100)</td>
<td>0.872</td>
<td>231</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at a level of 0.1; ** Significant at a level of 0.05; *** Significant at a level of 0.01.

Note: sample periods for all banks are 1999/07/01-2004/09/30.
Appendix: Test results of Ronn and Verma’s estimated method

Table 7: The Results of Testing Hypothesis 1 (Data Period: 1986/01/01-1999/06/30)

\[ \frac{D_{jt}}{V_{jt}} = \alpha_0 + \alpha_1 \sigma_{V_{jt}} + \varepsilon_{jt} \]

<table>
<thead>
<tr>
<th>Company name</th>
<th>Intercept</th>
<th>SIGMA_V</th>
<th>t</th>
<th>R^2</th>
<th>Sample period</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chang Haw Bank</td>
<td>0.869***</td>
<td>(0.7970)***</td>
<td>(6.59)</td>
<td>0.759</td>
<td>1990/04-1999/06/30</td>
<td>37</td>
</tr>
<tr>
<td>Hsinchu International Bank</td>
<td>0.711***</td>
<td>0.9900</td>
<td>80.73</td>
<td>0.993</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>International Bank of Taipei</td>
<td>0.572***</td>
<td>1.2248</td>
<td>25.54</td>
<td>0.943</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>Tainan Business Bank</td>
<td>0.718***</td>
<td>0.7319</td>
<td>46.34</td>
<td>0.980</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>Taitung Business Bank</td>
<td>0.571***</td>
<td>0.3390</td>
<td>17.58</td>
<td>0.919</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>Taichung Commercial Bank</td>
<td>0.879***</td>
<td>(1.2628)***</td>
<td>(8.15)</td>
<td>0.819</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>The Chinese Bank</td>
<td>0.885***</td>
<td>(0.4829)***</td>
<td>(2.36)</td>
<td>0.810</td>
<td>1996/01-1999/06/30</td>
<td>14</td>
</tr>
<tr>
<td>Cosmos Bank, Taiwan</td>
<td>0.896***</td>
<td>(0.6721)***</td>
<td>(2.05)</td>
<td>0.808</td>
<td>1995/10-1999/06/30</td>
<td>15</td>
</tr>
<tr>
<td>Union Bank of Taiwan</td>
<td>0.870***</td>
<td>(0.3104)*</td>
<td>(1.77)</td>
<td>0.846</td>
<td>1995/10-1999/06/30</td>
<td>15</td>
</tr>
<tr>
<td>Far Eastern International Bank</td>
<td>0.891***</td>
<td>(0.6611)*</td>
<td>(1.71)</td>
<td>0.768</td>
<td>1996/01-1999/06/30</td>
<td>14</td>
</tr>
<tr>
<td>Ta Chong Bank</td>
<td>0.883***</td>
<td>0.1273</td>
<td>1.66</td>
<td>0.810</td>
<td>1996/04-1999/06/30</td>
<td>13</td>
</tr>
<tr>
<td>Pooled Regression</td>
<td>0.663***</td>
<td>0.7393</td>
<td>28.46</td>
<td>0.683</td>
<td></td>
<td>378</td>
</tr>
</tbody>
</table>

* Significant at a level of 0.1;** Significant at a level of 0.05; *** Significant at a level of 0.01.

Table 8: The Results of Testing Hypothesis 1 (Data Period: 1999/07/01-2004/09/30)

\[ \frac{D_{jt}}{V_{jt}} = \alpha_0 + \alpha_1 \sigma_{V_{jt}} + \alpha_2 \text{Holding}_{jt} + \varepsilon_{jt} \]

<table>
<thead>
<tr>
<th>Company name</th>
<th>Intercept</th>
<th>SIGMA_V</th>
<th>t</th>
<th>Holding</th>
<th>t</th>
<th>R^2</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chang Haw Bank</td>
<td>0.964***</td>
<td>(0.8737)***</td>
<td>(2.65)</td>
<td>0.0029</td>
<td>0.38</td>
<td>0.650</td>
<td>21</td>
</tr>
<tr>
<td>Hsinchu International Bank</td>
<td>0.967***</td>
<td>(0.4324)***</td>
<td>(2.43)</td>
<td>0.0090</td>
<td>1.33</td>
<td>0.819</td>
<td>21</td>
</tr>
<tr>
<td>International Bank of Taipei</td>
<td>0.949***</td>
<td>(0.9734)***</td>
<td>(3.14)</td>
<td>0.0112</td>
<td>1.03</td>
<td>0.659</td>
<td>21</td>
</tr>
<tr>
<td>Tainan Business Bank</td>
<td>0.981***</td>
<td>(0.9100)***</td>
<td>(5.23)</td>
<td>0.0030</td>
<td>0.51</td>
<td>0.768</td>
<td>21</td>
</tr>
<tr>
<td>Taitung Business Bank</td>
<td>0.976***</td>
<td>(0.8315)***</td>
<td>(6.88)</td>
<td>0.0122**</td>
<td>1.92</td>
<td>0.865</td>
<td>21</td>
</tr>
<tr>
<td>Taichung Commercial Bank</td>
<td>0.970***</td>
<td>(0.6918)***</td>
<td>(3.14)</td>
<td>0.0001</td>
<td>0.02</td>
<td>0.673</td>
<td>21</td>
</tr>
<tr>
<td>The Chinese Bank</td>
<td>0.942***</td>
<td>(0.3035)*</td>
<td>(1.68)</td>
<td>0.0069*</td>
<td>1.88</td>
<td>0.566</td>
<td>21</td>
</tr>
<tr>
<td>Cosmos Bank, Taiwan</td>
<td>0.961***</td>
<td>(0.7001)***</td>
<td>(3.12)</td>
<td>0.0270**</td>
<td>(2.31)</td>
<td>0.838</td>
<td>21</td>
</tr>
<tr>
<td>Union Bank of Taiwan</td>
<td>0.952***</td>
<td>(0.3118)***</td>
<td>(1.79)</td>
<td>0.0070</td>
<td>1.06</td>
<td>0.555</td>
<td>21</td>
</tr>
<tr>
<td>Far Eastern International Bank</td>
<td>0.943***</td>
<td>(0.3465)*</td>
<td>(1.54)</td>
<td>0.0140</td>
<td>1.25</td>
<td>0.778</td>
<td>21</td>
</tr>
<tr>
<td>Ta Chong Bank</td>
<td>0.969***</td>
<td>(0.4130)***</td>
<td>(2.89)</td>
<td>0.0053</td>
<td>1.06</td>
<td>0.689</td>
<td>21</td>
</tr>
<tr>
<td>Pooled Regression</td>
<td>0.973***</td>
<td>(1.0988)***</td>
<td>(14.27)</td>
<td>0.0039</td>
<td>(0.84)</td>
<td>0.476</td>
<td>231</td>
</tr>
</tbody>
</table>

* Significant at a level of 0.1; ** Significant at a level of 0.05; *** Significant at a level of 0.01.

Note: sample periods for all banks are 1999/07/01-2004/09/30.
Table 9: The Results of Testing Hypothesis 2 (Data Period: 1986/01/01-1999/06/30)

\[ I_{jt} = \beta_{0j} + \beta_{1j}\sigma_{V_j} + \xi_{jt} \]

<table>
<thead>
<tr>
<th>Company name</th>
<th>Intercept</th>
<th>SIGMA_V</th>
<th>t</th>
<th>R²</th>
<th>Sample period</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chang Haw Bank</td>
<td>(0.0011)***</td>
<td>0.0226***</td>
<td>6.47</td>
<td>0.755</td>
<td>1990/04-1999/06/30</td>
<td>37</td>
</tr>
<tr>
<td>Hsinchu International Bank</td>
<td>(0.0099)***</td>
<td>0.1359***</td>
<td>214.56</td>
<td>0.999</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>International Bank of Taipei</td>
<td>(0.0385)***</td>
<td>0.3389***</td>
<td>53.33</td>
<td>0.983</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>Tainan Business Bank</td>
<td>(0.0125)*</td>
<td>0.1538***</td>
<td>146.24</td>
<td>0.998</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>Taitung Business Bank</td>
<td>(0.0279)**</td>
<td>0.1729***</td>
<td>73.38</td>
<td>0.991</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>Taichung Commercial Bank</td>
<td>(0.0008)*</td>
<td>0.0156***</td>
<td>5.82</td>
<td>0.789</td>
<td>1986/01-1999/06/30</td>
<td>54</td>
</tr>
<tr>
<td>The Chinese Bank</td>
<td>(0.0004)**</td>
<td>0.0115***</td>
<td>3.90</td>
<td>0.559</td>
<td>1990/04-1999/06/30</td>
<td>14</td>
</tr>
<tr>
<td>Cosmos Bank, Taiwan</td>
<td>(0.0009)*</td>
<td>0.0236***</td>
<td>2.92</td>
<td>0.479</td>
<td>1995/10-1999/06/30</td>
<td>15</td>
</tr>
<tr>
<td>Union Bank of Taiwan</td>
<td>(0.0038)**</td>
<td>0.0890***</td>
<td>5.70</td>
<td>0.782</td>
<td>1995/10-1999/06/30</td>
<td>15</td>
</tr>
<tr>
<td>Far Eastern International Bank</td>
<td>(0.0003)***</td>
<td>0.0075**</td>
<td>2.09</td>
<td>0.364</td>
<td>1990/04-1999/06/30</td>
<td>14</td>
</tr>
<tr>
<td>Ta Chong Bank</td>
<td>(0.0104)***</td>
<td>0.3167***</td>
<td>25.10</td>
<td>0.989</td>
<td>1996/04-1999/06/30</td>
<td>13</td>
</tr>
<tr>
<td>Pooled Regression</td>
<td>(0.0120)***</td>
<td>0.1360***</td>
<td>37.12</td>
<td>0.786</td>
<td></td>
<td>37</td>
</tr>
</tbody>
</table>

* Significant at a level of 0.1; ** Significant at a level of 0.05; *** Significant at a level of 0.01.

Table 10: The Results of Testing Hypothesis 2 (Data Period: 1999/07/01-2004/09/30)

\[ I_{jt} = \beta_{0j} + \beta_{1j}\sigma_{V_j} + \beta_{2j}Dholding_{jt} + \xi_{jt} \]

<table>
<thead>
<tr>
<th>Company name</th>
<th>Intercept</th>
<th>SIGMA_V</th>
<th>t</th>
<th>Holding</th>
<th>t</th>
<th>R²</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chang Haw Bank</td>
<td>(0.0005)**</td>
<td>0.0240***</td>
<td>3.31</td>
<td>0.00019</td>
<td>1.53</td>
<td>0.393</td>
<td>21</td>
</tr>
<tr>
<td>Hsinchu International Bank</td>
<td>(0.0006)**</td>
<td>0.0447***</td>
<td>3.53</td>
<td>(0.00001)</td>
<td>(0.05)</td>
<td>0.481</td>
<td>21</td>
</tr>
<tr>
<td>International Bank of Taipei</td>
<td>(0.0003)***</td>
<td>0.0143***</td>
<td>2.79</td>
<td>(0.00003)</td>
<td>(0.17)</td>
<td>0.400</td>
<td>21</td>
</tr>
<tr>
<td>Tainan Business Bank</td>
<td>(0.0007)**</td>
<td>0.0539***</td>
<td>5.69</td>
<td>0.00002</td>
<td>0.07</td>
<td>0.706</td>
<td>21</td>
</tr>
<tr>
<td>Taitung Business Bank</td>
<td>(0.0022)***</td>
<td>0.1001***</td>
<td>9.68</td>
<td>0.00110*</td>
<td>1.97</td>
<td>0.868</td>
<td>21</td>
</tr>
<tr>
<td>Taichung Commercial Bank</td>
<td>(0.0005)**</td>
<td>0.0392***</td>
<td>4.47</td>
<td>0.00009</td>
<td>0.59</td>
<td>0.547</td>
<td>21</td>
</tr>
<tr>
<td>The Chinese Bank</td>
<td>(0.0001)***</td>
<td>0.0098***</td>
<td>6.24</td>
<td>(0.00002)</td>
<td>(0.97)</td>
<td>0.684</td>
<td>21</td>
</tr>
<tr>
<td>Cosmos Bank, Taiwan</td>
<td>(0.0006)***</td>
<td>0.0400***</td>
<td>5.40</td>
<td>(0.00057)**</td>
<td>(2.12)</td>
<td>0.648</td>
<td>21</td>
</tr>
<tr>
<td>Union Bank of Taiwan</td>
<td>(0.0007)***</td>
<td>0.0415***</td>
<td>5.13</td>
<td>(0.00009)</td>
<td>(0.55)</td>
<td>0.595</td>
<td>21</td>
</tr>
<tr>
<td>Far Eastern International Bank</td>
<td>(0.0009)***</td>
<td>0.0373***</td>
<td>6.72</td>
<td>(0.00004)</td>
<td>(0.17)</td>
<td>0.763</td>
<td>21</td>
</tr>
<tr>
<td>Ta Chong Bank</td>
<td>(0.0009)***</td>
<td>0.0586***</td>
<td>5.62</td>
<td>0.00004</td>
<td>0.26</td>
<td>0.658</td>
<td>21</td>
</tr>
<tr>
<td>Pooled Regression</td>
<td>(0.0009)***</td>
<td>0.0480***</td>
<td>14.31</td>
<td>(0.00001)</td>
<td>(0.08)</td>
<td>0.475</td>
<td>231</td>
</tr>
</tbody>
</table>

* Significant at a level of 0.1; ** Significant at a level of 0.05; *** Significant at a level of 0.01.

Note: sample periods for all banks are 1999/07/01-2004/09/30.
Duan, J.-C., 2000, Correction for maximum likelihood estimation using price data of the derivative contract.