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COVID-19, insurer board utility, and capital regulation

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\section*{ABSTRACT}

This paper develops a down-and-out call option model by introducing a structural break in volatility to capture the coronavirus (COVID-19) outbreak. The life insurer’s equity and its board’s utility are evaluated at the optimal guaranteed rate in the equity maximization. Results suggest that the seriousness degree of the COVID-19 outbreak and capital regulation enhance the optimal guaranteed rate and the board’s utility. Increased the board’s utility by increasing liabilities costs insurer profitability. Conflicts of incentives can arise during the COVID-19 outbreak.

\section{1. Introduction}

There are two reports related to the coronavirus (COVID-19) outbreak paving the way for this paper since the outbreak has caused a crisis for the global markets. Brodzicki (2020) reports that the significantly increased global volatility due to the COVID-19 outbreak can adversely affect the prospects for a global recovery. Mao and Zhang (2020) report that the immediate impact of the COVID-19 outbreak on the global economy is inevitable. However, this COVID-19 outbreak does not harm all of the business opportunities. The life insurance business is a new business opportunity since people’s awareness of life and health has been enhanced and then stimulate demand for life and health insurance. We extend the reports by examining the impacts of the COVID-19 and capital regulation on the insurer’s optimal guaranteed rate and the board’s utility, which imply possible interest conflicts between the insurer and its board.

We focus on the COVID-19 for reasons. First, the outbreak of the COVID-19 is now the most significant Black Swan of 2020 (Brodzicki, 2020). Zhang et al. (2020) point out that the COVID-19 outbreak has significant impacts on the global financial markets and creates substantial volatility. Second, the risks the insurer faces are more evenly spread between the two sides of the balance sheet. Thus, asset-liability matching under capital regulation is a crucial issue from the standpoint of insurance stability (Insurance Europe, 2014). Third, we consider the effects of the COVID-19 outbreak and capital regulation on the optimal guaranteed rate-setting behavior and the board utility, possibly revealing conflicts of incentives. The recent literature remains silent on this issue.

In this paper, a model exploring the COVID-19 outbreak is proposed. For that purpose, a form of a structural break in volatility is introduced to evaluate the insurer’s equity value in a contingent claim model. The model also formulates the board utility to study the issue of interest conflicts. Moreover, deriving the comparative statics presents intuition and application in the paper.

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2. Framework model

Consider the insurer who makes all financial decisions during a period horizon, \( t \in [0, 1] \). This model applies Briys and de Varenne (1994), and more importantly, the COVID-19 outbreak is introduced to investigate the asset-liability matching management. The liability is specified as a profit-sharing policy including a guaranteed interest rate and participation in the terminal surplus. Insurer investment is core to the provision of profit-sharing policies. Accordingly, risks faced by insurers include investment risk, underwriting risk, and mismatch risk, which provide crucial information about the default probability that concerns insurers and regulators. We argue that the accounting approach does not take into account the risk information above. Insurance Europe (2014) further indicates that insurance liabilities are generally illiquid such as annuities entail predictable payments to policyholders; thus, insurance liabilities are a contingent rather than an unconditional claim. This is the reason why we develop a contingent claim model to evaluate the market value of the insurer's equity. Toward that end, we apply Briys and de Varenne (1994), and more importantly, the COVID-19 outbreak is introduced to investigate the asset-liability matching management. Technically speaking, the volatility of the underlying assets of the insurer reveals information about the equity risk in the call option valuation that we focus on.

We suppose that \( A = L + E = (1 - \alpha)A + \alpha A \) is the balance sheet where \((1 - \alpha)\) is the insurer's leverage.\(^1\) Accordingly, the market value of the underlying assets follows a geometric Brownian motion:

\[
d\Pi = \mu \Pi dt + \sigma \sqrt{\Pi} dW
\]

where \( \Pi = (1 + R_A)A \), where \( R_A \) is the risky asset-market rate, is the asset value with the expected return \( \mu > 0 \), and the structural break in volatility \( \sigma(\cdot + (\sigma^2/2)) \geq 0 \) in the spirit of Kohlodilin and Yao (2006) where \( \sigma \) is the expected volatility without the COVID-19 occurrence, \( \nu \) is the initial occurrence of the COVID-19 outbreak and \( \phi \) is the degree of influencing the insurer. The parameter \( (\nu + (\sigma^2/2)) > 0 \) is an impact factor of the COVID-19 outbreak, which, for simplicity, creates only a positive impact on the expected volatility.\(^2\) This form also measures the seriousness degree \( \phi \) of the COVID-19 to influence the insurer. \( \Omega \) is a standard Wiener process.

In the profit-sharing policy, we denote by \( \Theta = (1 - \alpha)Ae^\delta \), where \( R \) is the guaranteed interest rate set by the insurer (Polbrom, 1998). The book value of the liabilities plays as a strike price of the call option since the market value of the insurer's equity can be thought of as a call option on \( \Pi \). The market value of the equity \( \pi(\Pi, \Theta) \) will then be given by the formula of Briys and de Varenne (1994) for the call options: \(^3\)

\[
\pi(\Pi, \Theta) = \left[ \Pi N(d_1) - \Theta e^{-R_B N(d_2)} \right] - \delta \left[ (1 - \alpha) \Pi N(d_3) - \Theta e^{-R_B N(d_4)} \right]
\]

where

\[
N(\cdot) = \text{the cumulative density function of the standard normal distribution}
\]

and \( \delta \) is the participation level, and \( R_B \) is the security-market rate where the condition \( R < R_B < R_A \) is held. The difference between \( R_B \) and \( R \) is interpreted as the insurance compensation while the difference between \( R_A \) and \( R_B \) is interpreted as the investment risk compensation. Eq. (2) demonstrates a long call on \( \Pi \) with the strike price \( \Theta \) and a short call offsetting exactly the bouns call of the policyholders.

Next, we apply Hermalin (2005) by assuming the board's preference as a utility function that positively weights equity but negatively weights equity risk.\(^4\)

\[
U = (1 - P)\pi + P(-\pi_a)
\]

Eq. (3) consists of the weight-average net positive equity \((1 - P)\pi\) and the weight-average net negative equity risk \(P(-\pi_a)\) where \( P \) is the default probability (Vassalou and Xing, 2004) and \( \pi_a \) is the equity risk, that is the instantaneous standard deviations of the return on \( \pi \) (Ronnan and Verma, 1986). The first term can be interpreted as the board's like captured by the net real equity return and the second term can be interpreted as the board's dislike captured by the net real equity risk due to the default probability is explicitly expressed in the board utility function.

3. Solution and comparative statistics

Differentiating Eq. (2) with respect to \( R \), the first-order condition is \( \partial\pi(\Pi, \Theta)/\partial R = 0 \) where the optimal \( R \) is determined. The second-order condition \( \partial^2\pi(\Pi, \Theta)/\partial R^2 < 0 \) is satisfied. Next, differentiating the optimal \( R \) with respect to \( i \) \(( = \phi \) and \( \alpha \) yields:

\[
\frac{\partial R}{\partial i} = -\frac{\partial^2 \pi}{\partial R^2} \frac{\partial^2 \pi}{\partial R \partial i^2}
\]

Besides, differentiation of Eq. (3) evaluated at the optimal \( R \) with respect to \( i \) is given by:

\[
\frac{dU}{di} = \frac{\partial U}{\partial i} + \frac{\partial U}{\partial R} \frac{\partial R}{\partial i}
\]

\(^1\) For the derivation of the balance sheet, see Appendix 1.
\(^2\) It is also recognized that the expected return is influenced by the COVID-19. We are silent on this influence for simplicity. The qualitative results derived from the model are expected to remain unchanged when we add this complexity.
\(^3\) For the specifications of \( d_1 - d_4 \), see Appendix 2
\(^4\) For specifications of \( P \) and \( \pi_a \), see Appendix 3
where the first-term is the direct effect, which is the effect of the parameter $i$ on $U$, holding the optimal $R$ constant. The second term is the indirect effect, which is the effect of the parameter $i$ on $U$ through the adjustments of the optimal $R$. To investigate Eqs. (4) and (5), we adopt a numerical approach to provide intuition.

Numerical analyses are based on the following reasonable parameter baselines. The parameter values, unless stated otherwise, are assumed as follows. (i) Let $(R(\%), L)$ illustrate increasing from $(2.75, 307)$, $(3.00, 323)$, ... $(4.00, 347)$ to $(4.25, 348)$. (ii) The participation level $\delta = 0.85$ and capital regulation $\alpha = 0.08$. (iii) We assume $R_A = 6.00\%$ and $R_B = 4.50\%$, and the condition $R < R_B < R_A$ is held for our analysis. (iv) We assume $\sigma = 0.30$, $\nu = 0.20$, and $\mu = 0.30$.

Table 1 shows that an increase in the degree of the COVID-19 outbreak increases the life insurance policy businesses at an increased optimal guaranteed rate. Intuitively, as the seriousness of the COVID-19 has a significant impact on the investment risk, the insurer must now provide a return to a higher risk base. One way the insurer may attempt to augment its total returns is by increasing life insurance policies at an increased optimal guarantee rate for the asset-liability matching management purpose. Our result is in large supported by Mao and Zhang (2020) although who remain silent on the optimal guaranteed rate determination.

Table 2 presents that an increase in capital regulation increases the life insurance policies at an increased optimal guaranteed rate. An increase in capital regulation implies a decrease in the insurer’s leverage, leading to investment funds decreased. To keep sufficient funds for investment, the insurer will conduct its guaranteed rate-setting strategy to increase its life insurance contracts. Thus, policyholder protection increases at the cost of the decreased optimal insurer interest margin due to an increase in the guaranteed rate. Thereby, stringent capital regulation helps policyholder protection but harms the insurer’s interest margin, contributing to insurance stability during the COVID-19 outbreak period. Alpert (2020) reports that the Bank of England rolls out stimulus measures for the first time on March 11, 2020, mainly lowering capital requirements for U.K. financial institutions, which is money kept in reserve to increase institutions’ resistance to global COVID-19 shocks. This bailout allows nearly $390 billion in new lending investment. However, our result is different because the insurer can use its pricing strategy by increasing the optimal guaranteed rate to attract insurance businesses and thus funds available for investment are increased. Therefore, our result further complements and provides choices for the financial authorities: capital regulation to the insurer reaching the goal of policyholder protection and capital deregulation to the insurer achieving the goal of the profit maximization when the COVID-19 outbreak is considered.

Table 3 demonstrates that capital regulation enhances insurance businesses. The enhancement is reinforced when the COVID-19 outbreak becomes more serious. The serious COVID-19 harms the insurer’s investment return. For the asset-liability matching management, the insurer will increase its optimal guaranteed rate to attract more policies to substitute the increased capital reserves. Thus, stringent capital regulation helps policyholder protection, thereby contributing to insurance stability.

In Table 4, we show that the more serious COVID-19 outbreak directly enhances the board’s utility, holding the optimal guaranteed rate constant, since the increased equity risk is insufficient to offset the increased equity return. Moreover, an increase in the COVID-19 indirectly increases the board’s utility through optimal guaranteed-rate adjustments. The positive direct effect is mainly from the explicit consideration of equity return and risk, while the positive indirect effect considers the optimal guaranteed-rate

| Table 1 | Effect of the seriousness level of COVID-19 outbreak on the optimal guaranteed rate. |
|---------|---------------------------------------------------------------|
| $\varphi$ | $(R(\%), L)$ | $(3.00, 323)$ | $(3.25, 334)$ | $(3.50, 341)$ | $(3.75, 345)$ | $(4.00, 347)$ | $(4.25, 348)$ |
| | $\partial R/\partial \varphi \times 10^{-2}$ |
| $0.03 \rightarrow 0.05$ | – | 2.1224 | 1.8929 | 1.6987 | 1.6035 | 1.9253 | – |
| $0.05 \rightarrow 0.07$ | – | 2.1213 | 1.8918 | 1.6977 | 1.6025 | 1.9238 | – |
| $0.07 \rightarrow 0.09$ | – | 2.1202 | 1.8908 | 1.6967 | 1.6014 | 1.9223 | – |
| $0.09 \rightarrow 0.11$ | – | 2.1191 | 1.8898 | 1.6957 | 1.6004 | 1.9208 | – |
| $0.11 \rightarrow 0.13$ | – | 2.1180 | 1.8887 | 1.6947 | 1.5993 | 1.9193 | – |
| $0.13 \rightarrow 0.15$ | – | 2.1169 | 1.8877 | 1.6937 | 1.5983 | 1.9179 | – |

*Parameter values, unless stated otherwise, $R_A = 6.00\%$, $R_B = 4.50\%$, $\varphi = 0.03$, $\delta = 0.85$, $\sigma = 0.30$, $\mu = 0.30$ and $\nu = 0.20$. The shaded areas represent the values evaluated at the optimal $R = 4.00\%$.

| Table 2 | Effect of capital regulation on the optimal guaranteed rate. |
|---------|---------------------------------------------------------------|
| $\alpha$ | $(R(\%), L)$ | $(3.00, 323)$ | $(3.25, 334)$ | $(3.50, 341)$ | $(3.75, 345)$ | $(4.00, 347)$ | $(4.25, 348)$ |
| | $\partial R/\partial \alpha$ |
| $0.08 \rightarrow 0.10$ | – | 2.2613 | 1.9058 | 1.5509 | 1.2032 | 0.8956 | – |
| $0.10 \rightarrow 0.12$ | – | 2.2745 | 1.9206 | 1.5688 | 1.2280 | 0.9424 | – |
| $0.12 \rightarrow 0.14$ | – | 2.2770 | 1.9284 | 1.5840 | 1.2560 | 1.0052 | – |
| $0.14 \rightarrow 0.16$ | – | 2.2614 | 1.9235 | 1.5927 | 1.2860 | 1.0871 | – |
| $0.16 \rightarrow 0.18$ | – | 2.2210 | 1.9002 | 1.5903 | 1.3141 | 1.1849 | – |
| $0.18 \rightarrow 0.20$ | – | 2.1534 | 1.8556 | 1.5730 | 1.3352 | 1.2891 | – |

*Parameter values, unless stated otherwise, $R_A = 6.00\%$, $R_B = 4.50\%$, $\varphi = 0.03$, $\delta = 0.85$, $\sigma = 0.30$, $\mu = 0.30$ and $\nu = 0.20$. The shaded areas represent the values evaluated at the optimal $R = 4.00\%$. 
adjustments. The indirect effect reinforces the direct effect, leading to a positive effect on the board’s utility. In the setting of the board utility, conflicts of incentives between the manager and the board disappear. Accordingly, our result in large consistent with the argument of Mao and Zhang (2020): the life insurance business is one of the new opportunities during the COVID-19 period, implicitly implying that the board’s utility is increased.

In Table 5, we show that capital regulation enhances the board’s utility due to the safety net provided to the insurer and thus its board’s utility can be improved by requiring the insurer to operate with more capital during the COVID-19 outbreak. The result thereby contributes to insurance stability since insurer capital serves directly for policyholder protection (Insurance Europe, 2014). As reported by Daniels Trading (2020), the COVID-19 outbreak has been a primary driver of recent market volatility. Insurance is considered a transfer of risks from the insured to the insurer. It must have a level of capital, which enables it to absorb unfavorable risks and to be solvent (Araichi et al., 2016). Our result encompasses the suggestion of Araichi et al. (2016) since the guaranteed rate-setting behavior during the COVID-19 outbreak period is explicitly considered.

In Table 6, we describe that stringent capital regulation reduces the positive effect of the COVID-19 outbreak on the board’s utility. As the insurer is increasingly forced to increase its capital relative to the life insurance policy, it must increasingly provide a return to a larger equity base, yielding the board’s utility increasingly. Our result is in large consistent with Zhang et al. (2020): policy responses may create further uncertainty in financial [insurance] markets.
4. Conclusion

This paper proposes to explore the effects of the COVID-19 outbreak and capital regulation on the insurer's interest margin and its board utility. Results suggest that the COVID-19 outbreak and capital regulation increase insurance businesses at increased optimal guaranteed rates and enhance the board’s utility. One immediate application reveals the conflicts of incentives between the insurer and its board since an increase in the board utility at the cost of the insurer's liabilities from the standpoint of insurer profitability.

The model presented here is relatively fairly and should open at least one further avenue of research. An immediate outgrowth of the model is to introduce reinsurance options, particularly during the unexpected period of the COVID-19 outbreak. This is because the COVID-19 event has been a primary driver of market volatility. In conclusion, it is shown that guaranteed rate-setting behavior mode and capital regulation are intimately relevant to the COVID-19 outbreak.

CRediT authorship contribution statement

**Xuelian Li:** Conceptualization, Software, Formal analysis.  
**Panpan Lin:** Investigation, Writing - original draft.  
**Jyh-Horng Lin:** Supervision, Methodology, Validation, Writing - review & editing.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.frl.2020.101659.

Appendix

We support that the policyholders whose premium payments at $t = 0$ is denoted by $L = (1 - \alpha)A$ where $\alpha \in (0, 1)$, and the equity holders whose equity capital at $t = 0$ is denoted by $E = \alpha A$. $(1 - \alpha)$ captures leverage while $\alpha$ captures capital regulation.

Appendix 2:

\[
\begin{align*}
\varphi_1 &= \frac{1}{\sigma + (v + (\phi v^2/2))} \left( \ln \frac{\alpha \Pi}{\Theta} + R_B + \frac{\sigma + (v + (\phi v^2/2))}{2} \right) \\
\varphi_2 &= d_1 - \left[ \sigma + (v + (\phi v^2/2)) \right] \\
\varphi_3 &= \frac{1}{\sigma + (v + (\phi v^2/2))} \left( \ln \frac{\alpha \Pi}{\Theta} + R_B + \frac{\sigma + (v + (\phi v^2/2))}{2} \right) \\
\varphi_4 &= d_3 - \left[ \sigma + (v + (\phi v^2/2)) \right]
\end{align*}
\]

Appendix 3:

\[
\begin{align*}
P &= \frac{\Pi \mathbb{N}(d_1) - \Theta e^{-\Theta t}}{\pi} \mathbb{N}(-f_1) + \frac{\delta}{\pi} \left[ (1 - \alpha) \Pi \mathbb{N}(d_1) - \Theta e^{-\Theta t} \right] \mathbb{N}(-f_2) \\
f_1 &= \frac{1}{\sigma + (v + (\phi v^2/2))} \left( \ln \frac{\alpha \Pi}{\Theta} + \mu - \frac{(\sigma + (v + (\phi v^2/2)))^2}{2} \right) \\
f_2 &= \frac{1}{\sigma + (v + (\phi v^2/2))} \left[ \ln \frac{(1 - \alpha) \Pi}{\Theta} + \mu - \frac{(\sigma + (v + (\phi v^2/2)))^2}{2} \right]
\end{align*}
\]

Table 6

| $\Delta \alpha$ | $\psi$ | $dU/d\alpha$ |
|-----------------|-------|--------------|
| 0.08→0.10      | 0.03  | 24.7556      |
| 0.10→0.12      | 0.05  | 24.6400      |
| 0.12→0.14      | 0.07  | 24.5246      |
| 0.14→0.16      | 0.09  | 24.4095      |
| 0.16→0.18      | 0.11  | 24.2947      |
| 0.18→0.20      | 0.13  | 24.1802      |

*Parameter values, unless stated otherwise, $R_A = 6.00\%$, $R_B = 4.50\%$, $\delta = 0.85$, $\sigma = 0.30$, $(R(\%), L) = (4.00, 347)$, $\mu = 0.30$ and $v = 0.20$. All values are evaluated at the optimal guaranteed rate.
\[
\pi_a = \left( \sigma + \nu + \frac{\phi \nu^2}{2} \right)
\]

\[
\left[ \frac{\Pi (d_1) - \theta e^{-\delta N(d_2)}}{\Pi (d_1) - \theta e^{-\delta N(d_2)}} - \frac{\theta e^{-\delta N(d_2)}}{\Pi (d_1) - \theta e^{-\delta N(d_2)}} \right] \left[ \frac{\Pi (d_1) - \theta e^{-\delta N(d_2)}}{\Pi (d_1) - \theta e^{-\delta N(d_2)}} - \frac{\theta e^{-\delta N(d_2)}}{\Pi (d_1) - \theta e^{-\delta N(d_2)}} \right]
\]

\[
\frac{\delta \Pi (1 - \alpha) N(d_1) - \theta e^{-\delta N(d_2)}}{\delta \Pi (1 - \alpha) N(d_1) - \theta e^{-\delta N(d_2)}} \frac{\delta \Pi (1 - \alpha) N(d_1) - \theta e^{-\delta N(d_2)}}{\delta \Pi (1 - \alpha) N(d_1) - \theta e^{-\delta N(d_2)}}
\]

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