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A CALL OPTION FRAMEWORK FOR LOAN SWAP HEDGING UNDER GOVERNMENT CAPITAL INJECTION

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Abstract. *The call options theory of corporate security valuation is applied to the contingent claims of a bank conducting loan portfolio hedging diversification under government capital injection. We find that diversification is not guaranteed to produce efficiency gain. It is shown that hedging diversification transaction leads to superior equity return performance and greater safety for the bank; however, it results in increasing the efficiency loss from diversification. While we show that government capital injection helps increase bank equity return and decrease equity risk, we document detrimental effects on the efficiency loss from diversification. From a normative standpoint, our results suggest that the bailout program of government capital injection creates an incentive for banks to pursue hedging management strategies.*
Keywords: Hedging, Bank interest margin, Bank equity risk, Government capital injection, Efficiency

1. **Introduction.** Credit risk transfer tools have been extensively used by banks over the last decades to actively manage credit risk. Banks and other lenders transfer credit to release capital for further loan intermediation [1]. Bedendo and Bruno [2] suggest that in times of severe funding constraints in particular during the 2007-2009 crisis, the need to raise financial resources becomes a principal incentive behind credit risk transfer. During a financial crisis, capital levels of banks are depleted and raising new capital in public markets is difficult. Bayazitova and Shivdasani [3] suggest that the government capital injection of the Trouble Asset Relief Program can stabilize banks by providing a source of capital when public market alternatives are unavailable. Breitenfellner and Wagner [4] argue that with a government bailout, there is little incentive for bank to pursue sophisticated risk management strategies. Against this background, our focus attempts to address the following open questions. Is hedging by loan portfolio diversification guaranteed to produce superior performance and/or greater safety for the bank under government capital injection? Is hedging diversification efficient for the bank? Does government capital injection help manage bank risk? Does government capital injection lead to higher efficiency gain from hedging diversification for the bank?

Addressing those issues has relevant policy implications. First, it provides a direct assessment of the actions undertaken by regulators to preserve loan portfolio hedging diversification of credit risk transfer under government capital injection. Brunnermeier [5] argues that credit risk transfer practices spur excess credit growth and increase risk taking as a result of reduced monitoring incentives in credit risk transfer users. From a policy standpoint, it is interesting to ask whether an individual bank benefits or gets hurt from hedging diversification of its loan portfolio. Second, as pointed out by Duffie [1], credit risk transfer instruments enable banks to liberate capital. It is important to note that a better understanding of government capital injection affects the efficiency gain or loss from loan portfolio hedging diversification. In particular, we argue that hedging diversification and government assistance are linked through a channel of bank interest margin, i.e., the spread between the loan rate and the deposit rate, which is one of principal elements of bank cash flows and after-tax earnings. Indeed, the bank interest margin is often used in the literature as a proxy for the efficiency of financial intermediation [6].

In practice, spread management is done through a "cost of goods sold" approach in which deposits are the "material" and loans are the "work in process" [7]. Based on this practice of banking management, we apply Merton [8] that the equity of a banking firm is viewed as a call option on the bank's assets. The reason is that equity holders are residual claims on the bank's assets after all of the other obligations have been met. The strike price of the call is the book value of the bank's liabilities. When the value of the bank's assets is less than the strike price, the value of equity is zero. This approach, however, omits a key aspect of the behavior of bank intermediaries. It is assumed that asset market is perfectly competitive so that quantity-setting is the relevant behavioral mode in the market. This assumption is not applicable to loan markets since such markets are always highly concentrated where banks set rates and face random loan levels [9]. Neal [10] argues that banks tend to concentrate their loans geographically or in particular industries, which limits their ability to diversify across borrowers. The author further argues that credit swaps are appealing to commercial banks whose loan portfolios are concentrated in particular industries or geographic areas.

In light of previous work, the purpose of this paper is to develop a call option model of bank behavior that integrates the risk considerations of the portfolio-theoretic approach with the bailout conditions, cost and hedging considerations, and loan rate-setting behavioral mode of the firm-theoretic approach. Further, our approach in calculating hedging efficiency measures uses the Merton's [8] model with the explicit treatment of bank spread behavior under government capital injection, which contributes to an extensive literature on the effect of bank capital (or government capital injection to the bank) on bank margin, risk, and efficiency. The comparative static results of the model show that (i) loan portfolio hedging diversification may lead to efficiency loss; (ii) an increase in the hedging cost increases the optimal bank interest margin and the equity risk, and increases the efficiency loss from diversification; (iii) an increase in the loan portfolio swap diversification transaction increases the bank interest margin, decreases the equity risk, and increases the efficiency loss; (iv) an increase in the government capital injection increases the margin, decreases the equity risk, and decreases the efficiency loss.

The introduction of credit derivative markets has given banks a new risk management tool. These markets have shown a rapid growth. Wagner and Marsh [11] suggest that the recent development of credit derivative instrument is to be welcomed. Our results, the positive effect of loan swap hedging on bank interest margin and the negative effect on bank equity risk, confirm the suggestion of Wagner and Marsh [11]. However, hedge fund manager George Soros referred to credit default swap contracts as "toxic" and called for banning their use [12]. Our result, the positive effect of loan swap hedging on the efficiency loss from diversification, is consistent with the argument of Cullen [12].

In addition, the recent financial crisis raises a fundamental issue about the role of bank equity capital. Berger and Bouwman [13] argue that not surprisingly, public outcries for more bank capital tend to be greater after financial crisis, and post-crisis reform proposals tend to focus on how capital regulation should adapt to prevent future crises.[1] Our result, the negative effect of government capital injection (thereby bank capital) on hedging efficiency loss, is largely supported by the above argument of Berger and Bouwman [13].

Our results are derived that should be of interest to investors, banks, and policy makers. For example, as mentioned previously, hedging diversification may result in bank efficiency loss, which is not consistent with the traditional argument of Diamond [14] that banks should be as diversified as possible. A theoretical explanation for our argument may include bank interest margin determination under government capital injection that we add to the literature on bank efficiency. In addition, we argue that government capital injection produces superior performance and greater safety for the bank as well as reduced efficiency loss, which is consistent with Bayazitova and Shivdasani [3]. Moreover, both credit risk transfer and government capital injection liberate bank capital for further loan intermediation. We argue that government capital injection relative to credit risk transfer is efficient. Government capital injection as such contributes to the stability of the banking system.

The paper is organized as follows. Section 2 discusses related literature. A call option model of a bank is presented in Section 3. Section 4 derives the solution of the model and the comparative static results. Section 5 conducts a numerical exercise to explain the intuition of the comparative static results. The final section concludes the paper.

2. **Related Literature.** Our theory of loan portfolio focus versus hedging diversification is related to three strands of the literature. The first is the literature on bank interest margin. Bank interest margin covers vital information for the efficiency of the banking system [15]. The pioneering study by Ho and Saunders [16] has been the reference framework for many of contemporary studies of determinants of bank interest margins. The authors construct a dealership model and find that the interest margin depends on both the degree of market competition and the interest risk. The most recent extension is studied by Maudos and de Guevara [17], which include operating cost as an explicit component of interest margin. Their major findings suggest that operating cost, interest rate and credit risk, and management quality are positively related to bank interest margin. Kasman et al. [15] also utilize the dealership model and show that operating cost, credit risk, default risk, and capital adequacy are positively related to bank interest margin. While we also examine bank interest margin, our focus on the margin management with loan portfolio hedging diversification under government capital injection, with special emphasis on the call option valuation, takes our analysis in a different direction.

The second strand is the modern focus versus diversification literature. Traditional arguments based on Diamond [14] suggest that banks should be as diversified as possible. Winton [20] investigates the merit of the proverbial wisdom of not putting all one's eggs in one basket. DeLong [21] documents that bank mergers that are focusing in terms of geography and activity produce superior economic performance relative to those that are diversifying. Acharya et al. [22] study the effect of loan portfolio focus versus diversification on bank return and risk. Their findings suggest that diversification is not guaranteed to produce superior performance and/or greater safety for the bank. The primary difference between our model and these papers is that we consider the effects of loan portfolio hedging diversification under government capital injection on bank performance and efficiency gain/loss from diversification.

The third strand is the literature on government capital injection. Aghion et al. [23] examine optimal bailout policy for distress banks, optimal in sense that the bailout policy

[1]Various such proposals have been put forth recently, for example, Kashyap et al. [18], and Acharya et al. [19].

minimizes costs to the public, while providing round incentives to bank managers. The authors show that both hard and soft bailout policies have negative impacts on bank managers' incentives. Gorton and Huang [24] claim that the benefits of government bailouts depend on the type of liquidity shock faced by banks. They conclude that government bailouts via asset purchase are feasible in case banks face a capitalization shock. Acharya and Yorulmazer [25] suggest that the best way for the government to intervene is through the provision of liquidity to surviving banks. Hoshi and Kashyap [26] suggest that besides buying distressed assets, government assistance should also be conducted via direct equity injections to stabilize the banking system. In addition to government bailouts, a segment of the market for credit risk is the market for credit protection. Hedging by means of credit protection has an effect on the regulatory equity cushion as required by the financial authorities [4]. We add to the literature on government intervention by integrating loan portfolio hedging diversification in order to understand the interconnectedness between the loan market and the regulatory credit protection.

3. **The Model.** Consider a bank that makes decisions in a single-period horizon with two dates, 0 and 1, $t \in [0, 1]$.[2] At $t = 0$, the bank has the following balance sheet:

$$(1-\alpha)L + \alpha L + B = D + K + \theta K = (1+\theta)K\left(\frac{1}{q} + 1\right) \tag{1}$$

where $(1-\alpha)L > 0$ with the conditions of $0 \leq \alpha < 1$ and $L > 0$ is the amount of non-swapped loans in the credit risk transfer transaction, $\alpha L > 0$ is the amount of swapped loans, $B > 0$ is the volume of the risk-free liquid assets, $D > 0$ is the quantity of deposits, $K > 0$ is the stock of equity capital, θK is the capital injection from the government where $\theta > 0$, and q is a regulatory capital-to-deposits ratio [30]. Note that α measures the degree of loan portfolio swap diversification: the larger it is, the higher degree is the diversification relative to the focus.

Loans granted by the bank belong to a single homogeneous class of fixed-rate claims that mature at $t = 1$. The demand for loans faced by the bank is governed by a downward-sloping demand function $L(R_L)$ with the condition of $\partial L/\partial R_L < 0$, where $R_L > 0$ is the loan rate set by the bank [29]. Non-swapped loans are risky in that they subject to non-performance. Swapped loans become risk-free in that they are subject to a hedging cost $R_C > 0$ with the condition of $(R_L - R_C) > R > 0$, where R is the security market interest rate. This condition indicates an incentive for the bank to hedging its credit risk rather than shifting its investments from its loan portfolio to the liquid-asset market. The liquid assets held by the bank earn the interest rate of R. The supply of deposits is perfectly elastic at a market rate of $R_D > 0$.[3] The bank's equity capital is tied by regulation to be a fixed proportion q of its deposits, $(1+\theta)K = qD$, when the capital constraint is binding [31]. This paper focuses on this case.

With information about Equation (1), we describe the loan portfolio swap diversification gain based on an option valuation framework. The bank's objective is to set R_L to maximize the expected value of a call option function defined in terms of profits, subject

[2] Hung and Lin [27], Lin et al. [28], and Lin et al. [29] also construct a one-period option model to analyze the effect of technology choices, the accrual effect, and the effect of deposit insurance on bank spread behavior, respectively.

[3] For simplicity, we do not consider the deposit insurance premium paid by the bank in the model. Lin et al. [29] analyze loan-risk sensitive insurance premium in a realized capped call option model. Lin et al. [29] use a barrier-capped barrier option model to value actuarially fair deposit insurance premium.

to Equation (1). The selection of our model's objective function follows Merton [8].[4] Specifically, the proposed framework starts by viewing the market value of bank equity as a call option on the market value of loan repayments. The value of the underlying assets follows a geometric Brownian motion:

$$dV = \mu V dt + \sigma V dW \tag{2}$$

where

$$V = (1-\alpha)(1+R_L)L$$

and V is the non-swapped loan repayments with an instantaneous drift μ, an instantaneous volatility σ, and a standard Wiener process W.

By following Equation (2) with the balance sheet constraint of Equation (1), the market value of equity, S, will then be given by the Merton [8] formula for call options:

$$S = VN(d_1) - Ze^{-\delta}N(d_2) \tag{3}$$

where

$$Z = \frac{(1+R_D)(1+\theta)K}{q} - (1+R)\left[(1+\theta)K\left(\frac{1}{q}+1\right) - L\right] - \alpha(1+R_L-R_C)L$$

$$\delta = R - R_D$$

$$d_1 = \frac{1}{\sigma}\left(\ln\frac{V}{Z} + \delta + \frac{\sigma^2}{2}\right), \quad d_2 = d_1 - \sigma$$

and $Z \equiv$ the book value of the net-obligation payments, the difference between the payment to depositors and the repayments from the liquid-asset investment and from the credit risk transfer transection, $\delta \equiv$ the risk-free discount rate, and $N(\cdot) \equiv$ the cumulative density function of the standard normal distribution.

We next follow Ronn and Verma [32] and define the instantaneous standard deviation of the return on S as follows:

$$\sigma_S = \frac{V}{S}\frac{\partial S}{\partial V}\sigma = \frac{V}{S}N(d_1)\sigma \tag{4}$$

Given Equations (3) and (4), we can now compare the risk/return efficiency of the loan portfolio swap diversification with that of the loan portfolio without swap transaction, and determine the efficiency gain from swap diversification. Let $SHP(WD)$ denote the ratio of excess return to standard deviation of the loan portfolio swap and $SHP(OD)$ denote the same ratio for the loan focus. In other words,

$$SHP(WD) = \frac{S(0<\alpha<1) - (1+R)(1+\theta)K}{\sigma_S(0<\alpha<1)} \tag{5}$$

and

$$SHP(OD) = \frac{S(\alpha=0) - (1+R)(1+\theta)K}{\sigma_S(\alpha=0)} \tag{6}$$

Then, the efficiency gain/loss from swap diversification can be measured by the SHP differential:

$$\Delta SHP = SHP(WD) - SHP(OD) \tag{7}$$

The SHP differential measures the mean return differential, per unit of standard deviation, that accrues from holding the loan portfolio with swap diversification in lieu of the loan focus. Equation (7) can be used to question whether the bank benefits ($\Delta SHP > 0$) or gets hurt ($\Delta SHP < 0$) from hedging diversification of its loan portfolio.

[4]Note that imperfectly competitive loan market considered in our model is ignored in Merton [8]. Results to be derived from our model do not extend to the case where the loan market faced by the bank is perfectly competitive.

4. **Solution and Results.** Partially differentiating Equation (3) with respect to R_L, the first-order condition is given by:

$$\frac{\partial S}{\partial R_L} = \frac{\partial V}{\partial R_L} N(d_1) + V \frac{\partial N(d_1)}{\partial d_1} \frac{\partial d_1}{\partial R_L} - \frac{\partial Z}{\partial R_L} e^{-\delta} N(d_2) - Z e^{-\delta} \frac{\partial N(d_2)}{\partial d_2} \frac{\partial d_2}{\partial R_L} = 0 \quad (8)$$

We require that the second-order condition be satisfied, $\partial^2 S/\partial R_L^2 < 0$. The optimal loan rate can be chosen based on Equation (8) where the marginal loan repayments of loan rate equal the marginal net-obligation payments. We can further substitute the optimal rate to obtain ΔSHP remaining on the optimization.

Having examined the solution to the bank's optimization problem, we further consider the effects on the optimal loan rate (and thus the optimal bank interest marginal), the standard deviation of the equity return, and the efficiency gain from swap diversification from changes in the parameters of the model. Based on Equations (8), (4), and (7), we have the following comparative static results, respectively:

$$\frac{\partial R_L}{\partial A} = -\frac{\partial^2 S}{\partial R_L \partial A} \bigg/ \frac{\partial^2 S}{\partial R_L^2} \quad (9)$$

$$\frac{d\sigma_S}{dA} = \frac{\partial \sigma_S}{\partial A} + \frac{\partial \sigma_S}{\partial R_L} \frac{\partial R_L}{\partial A} \quad (10)$$

$$\frac{d\Delta SHP}{dA} = \frac{\partial \Delta SHP}{\partial A} + \frac{\partial \Delta SHP}{\partial R_L} \frac{\partial R_L}{\partial A} \quad (11)$$

where $A = R_C$, α, or θ.

In general, the added complexity of the call option does not always lead to clear-cut results in Equations (9), (10), and (11). However, we can speak of tendencies for reasonable numerical parameter levels corresponding roughly to a hypothetical bank. Toward that end, we compute derivatives of the value function of the call option. The numerical examples provide intuition regarding the problems at hand, for example, the comparative static results of Equations (9), (10), and (11) in the model.

Table 1. Responsiveness of bank interest margin to hedging cost

	$(R_L\%, L)$						
$R_C\%$	$(4.5, 200)$	$(4.6, 199)$	$(4.7, 197)$	$(4.8, 194)$	$(4.9, 190)$	$(5.0, 185)$	$(5.1, 179)$
	S						
0.1	34.2912	34.3181	34.2290	34.0228	33.6982	33.2547	32.6917
0.2	34.2791	34.3060	34.2170	34.0109	33.6865	33.2432	32.6804
0.3	34.2671	34.2940	34.2051	33.9990	33.6748	33.2317	32.6692
0.4	34.2550	34.2819	34.1931	33.9872	33.6631	33.2202	32.6580
0.5	34.2429	34.2699	34.1811	33.9753	33.6514	33.2087	32.6467
0.6	34.2309	34.2578	34.1691	33.9634	33.6397	33.1972	32.6355
	$\partial R_L/\partial R_C (10^{-4})$						
$0.1 \to 0.2$	–	1.6231	5.5770	9.5009	13.4272	17.3997	–
$0.2 \to 0.3$	–	1.6222	5.5764	9.5007	13.4272	17.4002	–
$0.3 \to 0.4$	–	1.6213	5.5758	9.5004	13.4273	17.4006	–
$0.4 \to 0.5$	–	1.6204	5.5753	9.5001	13.4274	17.4010	–
$0.5 \to 0.6$	–	1.6196	5.5747	9.4999	13.4275	17.4015	–

Notes: Parameter values, unless stated otherwise: $R = 3.5\%$, $R_D = 2.5\%$, $K = 15$, $q = 8.5\%$, $\sigma = 0.3$, $\alpha = 0.1$, and $\theta = 0.1$. The computed results of $\partial^2 S/\partial R_L^2$ at various levels of R_C are consistently negative in sign, which confirms the required second-order condition of Equation (8). The values in the shaded areas are computed based on an approximate optimal loan rate of 4.6%.

5. **Numerical Analysis.** In the following numerical analysis, the parameter values, unless otherwise indicated, are assumed to be $R = 3.5\%$, $R_D = 2.5\%$, $K = 15$, $q = 8.5\%$, and $\sigma = 0.3$. Let $(R_L\%, L)$ change from $(4.5, 200)$ to $(5.1, 179)$ due to the conditions of $\partial L/\partial R_L < 0$ and $\partial^2 L/\partial R_L^2 < 0$. These parameter levels for simulation exercises are explained as follows.

(i) The assumption of $R_L > R = 3.5\%$ indicates that there is scope for earning-asset portfolio substitution [33]. The assumption of $R > R_D = 2.5\%$ implies that the capital constraint is binding. The condition of $R_L > R_D$ demonstrates that the bank interest margin is recognized as one of the primary elements of after-tax earnings.

(ii) The specification of capital adequacy requirement is consistent with the Basel approach, which is set by the capital-to-deposits ratio $q = (1 + \theta)K/D = 8.5\%$ [30]. In the case where $\theta = 0$, the capital-to-asset ratio at $t = 0$ is $K/L = 15/200 = 7.5\%$, which does not meet the capital adequacy requirement of 8.0%. This distressed situation explains the bank's capital level is depleted. In the case where $\theta = 0.1$, the capital-to-asset ratio at $t = 0$ is $(15 + 1.5)/200 = 8.25\%$, which meets the requirement. This explains the government capital injection is anticipated by the bank in distress when the bank's raising new capital in public markets is difficult [3].

TABLE 2. Responsiveness of bank equity risk to hedging cost

	$(R_L\%, L)$						
$R_C\%$	$(4.5, 200)$	$(4.6, 199)$	$(4.7, 197)$	$(4.8, 194)$	$(4.9, 190)$	$(5.0, 185)$	$(5.1, 179)$
	σ_S						
0.1	1.1821	1.1794	1.1758	1.1712	1.1655	1.1585	1.1502
0.2	1.1823	1.1796	1.1760	1.1714	1.1657	1.1587	1.1504
0.3	1.1825	1.1798	1.1762	1.1716	1.1659	1.1589	1.1506
0.4	1.1827	1.1800	1.1764	1.1718	1.1661	1.1591	1.1508
0.5	1.1829	1.1802	1.1766	1.1720	1.1662	1.1593	1.1510
0.6	1.1831	1.1804	1.1768	1.1722	1.1664	1.1595	1.1512
	$\partial\sigma_S/\partial R_C$: direct effect (‰)						
$0.1 \to 0.2$	1.9438	1.9409	1.9375	1.9338	1.9295	1.9247	1.9191
$0.2 \to 0.3$	1.9439	1.9409	1.9376	1.9339	1.9296	1.9248	1.9192
$0.3 \to 0.4$	1.9439	1.9410	1.9377	1.9339	1.9297	1.9249	1.9193
$0.4 \to 0.5$	1.9440	1.9411	1.9378	1.9340	1.9298	1.9249	1.9194
$0.5 \to 0.6$	1.9441	1.9412	1.9379	1.9341	1.9299	1.9250	1.9195
	$(\partial\sigma_S/\partial R_L)(\partial R_L/\partial R_C)$: indirect effect ($10^{-5}$)						
$0.1 \to 0.2$	–	−0.4340	−2.0197	−4.3919	−7.6684	−12.0542	–
$0.2 \to 0.3$	–	−0.4338	−2.0197	−4.3922	−7.6690	−12.0553	–
$0.3 \to 0.4$	–	−0.4336	−2.0197	−4.3924	−7.6696	−12.0565	–
$0.4 \to 0.5$	–	−0.4335	−2.0197	−4.3927	−7.6702	−12.0576	–
$0.5 \to 0.6$	–	−0.4333	−2.0197	−4.3929	−7.6708	−12.0588	–
	$d\sigma_S/dR_C$: total effect (‰)						
$0.1 \to 0.2$	–	1.9365	1.9173	1.8899	1.8529	1.8041	–
$0.2 \to 0.3$	–	1.9366	1.9174	1.8899	1.8529	1.8042	–
$0.3 \to 0.4$	–	1.9367	1.9175	1.8900	1.8530	1.8043	–
$0.4 \to 0.5$	–	1.9368	1.9176	1.8901	1.8531	1.8044	–
$0.5 \to 0.6$	–	1.9368	1.9177	1.8902	1.8532	1.8044	–

Notes: Parameter values, unless stated otherwise: $R = 3.5\%$, $R_D = 2.5\%$, $K = 15$, $q = 8.5\%$, $\sigma = 0.3$, $\alpha = 0.1$, and $\theta = 0.1$. The values in the shaded areas are computed based on an approximate optimal loan rate of 4.6% observed from Table 1.

(iii) Using descriptive sample statistics for firms provided by Brockman and Turtle [34]: the mean value of asset volatility is 0.2904 with a corresponding standard deviation of 0.2608, we assume $\sigma = 0.3$ used in our numerical analysis.

5.1. **Increases in hedging cost.** The findings based on Equations (9), (10), and (11) are summarized in Tables 1, 2, and 3, respectively, where $A = R_C$, $\alpha = 0.1$, and $\theta = 0.1$. Note that the parameter value of R_C is various from 0.1% to 0.6% due to the condition of $(R_L - R_C) > R$, as mentioned previously.

In Table 1, we have the results of $S > 0$ and $\partial R_L/\partial R_C > 0$. It is interesting that, as the hedging cost in the credit risk transfer transaction increases, the optimal bank interest margin is increased. The result is understood because the bank must now provide a return based on a higher hedging cost base, as the hedging cost increases. One way the bank may attempt to augment its total returns is by shifting its investments from its loan portfolio to the liquid-asset market. If loan demand is relatively rate-elastic, a downside scale of loan portfolio is possible at an increased margin. Accordingly, the bank passes the burden of rising hedging expenses to borrowers by widening the bank interest margin. This result

Table 3. Responsiveness of efficiency gain to hedging cost

	$(R_L\%, L)$						
$R_C\%$	$(4.5, 200)$	$(4.6, 199)$	$(4.7, 197)$	$(4.8, 194)$	$(4.9, 190)$	$(5.0, 185)$	$(5.1, 179)$
	ΔSHP						
0.1	−1.7776	−1.7653	−1.7430	−1.7108	−1.6684	−1.6159	−1.5529
0.2	−1.7902	−1.7779	−1.7556	−1.7233	−1.6808	−1.6281	−1.5650
0.3	−1.8028	−1.7905	−1.7682	−1.7358	−1.6932	−1.6403	−1.5770
0.4	−1.8154	−1.8031	−1.7808	−1.7483	−1.7056	−1.6526	−1.5890
0.5	−1.8280	−1.8157	−1.7933	−1.7608	−1.7180	−1.6648	−1.6011
0.6	−1.8406	−1.8283	−1.8059	−1.7733	−1.7304	−1.6770	−1.6131
	$\partial\Delta SHP/\partial R_C$: direct effect (%)						
$0.1 \to 0.2$	−12.5999	−12.6181	−12.5922	−12.5217	−12.4063	−12.2458	−12.0402
$0.2 \to 0.3$	−12.5933	−12.6115	−12.5856	−12.5152	−12.3999	−12.2395	−12.0340
$0.3 \to 0.4$	−12.5867	−12.6049	−12.5790	−12.5087	−12.3934	−12.2331	−12.0277
$0.4 \to 0.5$	−12.5801	−12.5983	−12.5725	−12.5021	−12.3869	−12.2267	−12.0215
$0.5 \to 0.6$	−12.5735	−12.5917	−12.5659	−12.4956	−12.3805	−12.2203	−12.0152
	$(\partial\Delta SHP/\partial R_L)(\partial R_L/\partial R_C)$: indirect effect ($10^{-4}$)						
$0.1 \to 0.2$	–	0.2004	1.2418	3.0647	5.6855	9.1443	–
$0.2 \to 0.3$	–	0.2000	1.2431	3.0713	5.7010	9.1725	–
$0.3 \to 0.4$	–	0.1996	1.2444	3.0779	5.7165	9.2006	–
$0.4 \to 0.5$	–	0.1992	1.2457	3.0845	5.7320	9.2288	–
$0.5 \to 0.6$	–	0.1988	1.2470	3.0911	5.7475	9.2569	–
	$d\Delta SHP/dR_C$: total effect (%)						
$0.1 \to 0.2$	–	−12.6161	−12.5798	−12.4911	−12.3495	−12.1544	–
$0.2 \to 0.3$	–	−12.6095	−12.5732	−12.4845	−12.3429	−12.1477	–
$0.3 \to 0.4$	–	−12.6029	−12.5666	−12.4779	−12.3362	−12.1411	–
$0.4 \to 0.5$	–	−12.5963	−12.5600	−12.4713	−12.3296	−12.1344	–
$0.5 \to 0.6$	–	−12.5897	−12.5534	−12.4647	−12.3230	−12.1278	–

Notes: Parameter values, unless stated otherwise: $R = 3.5\%$, $R_D = 2.5\%$, $K = 15$, $q = 8.5\%$, $\sigma = 0.3$, $\alpha = 0.1$, and $\theta = 0.1$ The values in the shaded areas are computed based on an approximate optimal loan rate of 4.6% observed from Table 1.

is implicitly consistent with the findings of Kasman et al. [15] that bank interest margins are positively related to hedging (operating) cost.

The results obtained from Table 2 are based on the computation of Equation (10) where $A = R_C$. The direct effect captures an increase in σ_S due to an increase in R_C, holding the optimal bank interest margin constant. The positive direct effect observed from the second panel is understood because an increase in R_C makes credit risk transactions more costly to conduct. In response to this, the bank has a disincentive to conduct credit risk transfer transaction and hence increase bank equity risk, ceteris paribus. The indirect effect observed from the third panel is negative in sign. This is because an increase in R_C leads to an increase in the optimal loan and a decrease in the volume of loans (and thus a decrease in the bank's equity risk). Since the negative indirect effect is not sufficient to offset the positive direct effect, a total positive response of σ_S to an increase in R_C is observed from the last panel. This implies that the bank passes the burden of rising hedging expenses to borrowers, resulting in increasing credit risk in bank lending and enhancing bank equity risk. Counterparty credit risk in the hedging diversification transaction is a source of hedging cost. Arora et al. [35] argue that a market participant could suffer losses through the bankruptcy of a counterparty which is through the collateral channel. Our finding is largely supported by the argument above.

It is necessary to elaborate on the issue of efficiency gain from swap hedging diversification at various levels of hedging cost. We have the result of $\Delta SHP < 0$ observed from the first panel of Table 3. This result demonstrates that the bank can potentially hurt form loan portfolio hedging diversification at a given level of hedging cost. Our result may be consistent with an empirical finding of D'Souza and Lai [36], and bank efficiency is not significant. It is interesting that, as the hedging cost increases, the efficiency loss is increased captured by the negative direct effect observed form the second panel, while the efficiency loss is decreased captured by the positive indirect effect observed from the third panel. The indirect effect is insufficient to offset the negative direct effect to give an

Table 4. Responsiveness of bank interest margin to swap diversification transaction

	$(R_L\%, L)$						
α	$(4.5, 200)$	$(4.6, 199)$	$(4.7, 197)$	$(4.8, 194)$	$(4.9, 190)$	$(5.0, 185)$	$(5.1, 179)$
	S						
0.1	34.2429	34.2699	34.1811	33.9753	33.6514	33.2087	32.6467
0.2	31.8000	31.8422	31.7827	31.6204	31.3544	30.9839	30.5089
0.3	29.4114	29.4700	29.4413	29.3243	29.1181	28.8223	28.4369
0.4	27.1036	27.1805	27.1849	27.1158	26.9724	26.7545	26.4625
0.5	24.9236	25.0215	25.0622	25.0447	24.9683	24.8332	24.6397
0.6	22.9585	23.0818	23.1636	23.2030	23.1997	23.1535	23.0651
	$\partial R_L/\partial\alpha$						
$0.1 \to 0.2$	–	0.1312	0.2504	0.3684	0.4866	0.6064	–
$0.2 \to 0.3$	–	0.1619	0.2998	0.4364	0.5736	0.7139	–
$0.3 \to 0.4$	–	0.2098	0.3737	0.5365	0.7008	0.8704	–
$0.4 \to 0.5$	–	0.2907	0.4935	0.6952	0.9004	1.1149	–
$0.5 \to 0.6$	–	0.4415	0.7063	0.9699	1.2398	1.5262	–

Notes: Parameter values, unless stated otherwise: $R = 3.5\%$, $R_D = 2.5\%$, $K = 15$, $q = 8.5\%$, $\sigma = 0.3$, $R_C = 0.5\%$, and $\theta = 0.1$. The values in the shaded areas are computed based on an approximate optimal loan rate of 4.6% when $0.1 \leq \alpha \leq 0.3$, 4.7% when $0.4 \leq \alpha \leq 0.5$, and 4.8% when $\alpha = 0.6$. The corresponding results are confirmed by the validness of the second-order condition.

TABLE 5. Responsiveness of bank equity risk to swap diversification transaction

	$(R_L\%, L)$						
α	$(4.5, 200)$	$(4.6, 199)$	$(4.7, 197)$	$(4.8, 194)$	$(4.9, 190)$	$(5.0, 185)$	$(5.1, 179)$
	σ_S						
0.1	1.1829	1.1802	1.1766	1.1720	1.1662	1.1593	1.1510
0.2	1.1586	1.1556	1.1516	1.1464	1.1400	1.1323	1.1230
0.3	1.1276	1.1242	1.1196	1.1138	1.1065	1.0978	1.0872
0.4	1.0867	1.0828	1.0775	1.0707	1.0624	1.0523	1.0402
0.5	1.0303	1.0257	1.0195	1.0116	1.0018	0.9900	0.9759
0.6	0.9482	0.9426	0.9352	0.9257	0.9140	0.9000	0.8832
	$\partial\sigma_S/\partial\alpha$: direct effect						
$0.1 \to 0.2$	−0.2426	−0.2458	−0.2501	−0.2556	−0.2624	−0.2706	−0.2803
$0.2 \to 0.3$	−0.3099	−0.3140	−0.3194	−0.3263	−0.3348	−0.3451	−0.3573
$0.3 \to 0.4$	−0.4093	−0.4145	−0.4215	−0.4304	−0.4413	−0.4544	−0.4700
$0.4 \to 0.5$	−0.5639	−0.5708	−0.5801	−0.5918	−0.6062	−0.6233	−0.6436
$0.5 \to 0.6$	−0.8215	−0.8308	−0.8432	−0.8588	−0.8778	−0.9002	−0.9262
	$(\partial\sigma_S/\partial R_L)(\partial R_L/\partial\alpha)$: indirect effect						
$0.1 \to 0.2$	–	−0.0035	−0.0091	−0.0170	−0.0278	−0.0420	–
$0.2 \to 0.3$	–	−0.0048	−0.0122	−0.0226	−0.0367	−0.0553	–
$0.3 \to 0.4$	–	−0.0071	−0.0172	−0.0315	−0.0507	−0.0764	–
$0.4 \to 0.5$	–	−0.0114	−0.0262	−0.0470	−0.0750	−0.1125	–
$0.5 \to 0.6$	–	−0.0203	−0.0440	−0.0769	−0.1211	−0.1801	–
	$d\sigma_S/d\alpha$: total effect						
$0.1 \to 0.2$	–	−0.2493	−0.2592	−0.2727	−0.2902	−0.3126	–
$0.2 \to 0.3$	–	−0.3188	−0.3315	−0.3489	−0.3715	−0.4004	–
$0.3 \to 0.4$	–	−0.4216	−0.4386	−0.4618	−0.4920	−0.5308	–
$0.4 \to 0.5$	–	−0.5822	−0.6062	−0.6388	−0.6812	−0.7358	–
$0.5 \to 0.6$	–	−0.8511	−0.8872	−0.9357	−0.9988	−1.0803	–

Notes: Parameter values, unless stated otherwise: $R = 3.5\%$, $R_D = 2.5\%$, $K = 15$, $q = 8.5\%$, $\sigma = 0.3$, $R_C = 0.5\%$, and $\theta = 0.1$. The values in the shaded areas are computed based on approximate optimal loan rate of 4.6% when $0.1 \leq \alpha \leq 0.3$, 4.7% when $0.4 \leq \alpha \leq 0.5$, and 4.8% when $\alpha = 0.6$ observed from Table 4.

overall negative response of efficiency loss to an increase in the hedging cost observed from the last panel. This indicates that an increase in the hedging cost leads to an increase in efficiency loss from loan portfolio hedging diversification for the bank. The intuition is straightforward. An increase in the hedging cost increases the operation cost and hence decreases the bank's equity return. In the meanwhile, an increase in the hedging cost increases the bank's equity risk, as mentioned previously. Accordingly, the efficiency loss from swap hedging diversification is increased due to an increase in the hedging cost. Our findings are consistent with Arora et al. [35]: credit risk transfer in market participants suffers losses due to the hedging cost burden.

5.2. **Increases in loan portfolio swap diversification transaction.** The findings based on Equations (9), (10), and (11) are summarized in Tables 4, 5, and 6, respectively, where $0.1 \leq A = \alpha \leq 0.6$, $R_C = 0.5\%$, and $\theta = 0.1$.

The result of $\partial R_L/\partial\alpha > 0$ observed from the last panel in Table 4 demonstrates that an increase in the amount of the swap hedging diversification transaction increases the optimal bank interest margin. The result is understood because the bank provides a

TABLE 6. Responsiveness of efficiency gain to swap diversification transaction

	$(R_L\%, L)$						
α	$(4.5, 200)$	$(4.6, 199)$	$(4.7, 197)$	$(4.8, 194)$	$(4.9, 190)$	$(5.0, 185)$	$(5.1, 179)$
	ΔSHP						
0.1	−1.8280	−1.8157	−1.7933	−1.7608	−1.7180	−1.6648	−1.6011
0.2	−3.6326	−3.6066	−3.5603	−3.4935	−3.4059	−3.2972	−3.1671
0.3	−5.4016	−5.3599	−5.2873	−5.1834	−5.0479	−4.8803	−4.6798
0.4	−7.1133	−7.0524	−6.9495	−6.8041	−6.6156	−6.3832	−6.1058
0.5	−8.7243	−8.6380	−8.4978	−8.3030	−8.0526	−7.7450	−7.3786
0.6	−10.1369	−10.0132	−9.8219	−9.5618	−9.2312	−8.8278	−8.3488
	$\partial\Delta SHP/\partial\alpha$: direct effect						
$0.1 \to 0.2$	−18.0458	−17.9092	−17.6698	−17.3267	−16.8787	−16.3240	−15.6606
$0.2 \to 0.3$	−17.6906	−17.5328	−17.2694	−16.8991	−16.4202	−15.8305	−15.1268
$0.3 \to 0.4$	−17.1168	−16.9246	−16.6219	−16.2070	−15.6774	−15.0298	−14.2597
$0.4 \to 0.5$	−16.1095	−15.8563	−15.4839	−14.9894	−14.3692	−13.6179	−12.7284
$0.5 \to 0.6$	−14.1266	−13.7519	−13.2404	−12.5873	−11.7862	−10.8283	−9.7017
	$(\partial\Delta SHP/\partial R_L)(\partial R_L/\partial\alpha)$: indirect effect						
$0.1 \to 0.2$	–	0.0161	0.0560	0.1199	0.2083	0.3226	–
$0.2 \to 0.3$	–	0.0420	0.1388	0.2917	0.5025	0.7757	–
$0.3 \to 0.4$	–	0.0875	0.2715	0.5573	0.9496	1.4591	–
$0.4 \to 0.5$	–	0.1771	0.5079	1.0107	1.6969	2.5911	–
$0.5 \to 0.6$	–	0.3808	0.9900	1.8895	3.1056	4.6936	–
	$d\Delta SHP/d\alpha$: total effect						
$0.1 \to 0.2$	–	−17.8931	−17.6138	−17.2068	−16.6704	−16.0014	–
$0.2 \to 0.3$	–	−17.4908	−17.1306	−16.6074	−15.9177	−15.0547	–
$0.3 \to 0.4$	–	−16.8371	−16.3504	−15.6498	−14.7279	−13.5707	–
$0.4 \to 0.5$		−15.6792	−14.9760	−13.9788	−12.6723	−11.0268	–
$0.5 \to 0.6$	–	−13.3711	−12.2504	−10.6979	−8.6806	−6.1347	–

Notes: Parameter values, unless stated otherwise: $R = 3.5\%$, $R_D = 2.5\%$, $K = 15$, $q = 8.5\%$, $\sigma = 0.3$, $R_C = 0.5\%$, and $\theta = 0.1$. The values in the shaded areas are computed based on approximate optimal loan rate of 4.6% when $0.1 \le \alpha \le 0.3$, 4.7% when $0.4 \le \alpha \le 0.5$, and 4.8% when $\alpha = 0.6$ observed from Table 4.

return based on a larger risk-free asset base when the hedging transaction increases. One way the bank may attempt to augment its total returns is by shifting its investments to the liquid-asset market from its loan portfolio at an increased loan rate. This result emphasizes the impact of hedging diversification on loan scale which is perfectly in line with the bank's objective of making failure less likely. Moreover, under the assumption that swap hedging transaction helps mitigate the underinvestment problem in the business sector, one would expect the impact of the transaction on loan growth to strengthen [37]. However, Bedendo and Bruno [2] argue that banks may be tempted to use the resources generated through swap hedging transaction to reconstitute liquidity on reduce leverage rather than provide credit to the real economy. Our result is consistent with the argument above.

Table 7. Responsiveness of bank interest margin to government capital injection

	$(R_L\%, L)$						
θ	$(4.5, 200)$	$(4.6, 199)$	$(4.7, 197)$	$(4.8, 194)$	$(4.9, 190)$	$(5.0, 185)$	$(5.1, 179)$
	S						
0.1	34.2429	34.2699	34.1811	33.9753	33.6514	33.2087	32.6467
0.2	35.2965	35.3271	35.2433	35.0439	34.7280	34.2949	33.7446
0.3	36.3727	36.4070	36.3284	36.1358	35.8283	35.4055	34.8677
0.4	37.4715	37.5097	37.4365	37.2509	36.9522	36.5403	36.0157
0.5	38.5929	38.6350	38.5674	38.3892	38.0998	37.6993	37.1885
0.6	39.7369	39.7829	39.7211	39.5505	39.2708	38.8823	38.3861
	$\partial R_L/\partial\theta$ (%)						
$0.1 \rightarrow 0.2$	–	3.1583	4.2680	5.4308	6.6963	8.1276	–
$0.2 \rightarrow 0.3$	–	3.2743	4.4979	5.7822	7.1838	8.7751	–
$0.3 \rightarrow 0.4$	–	3.3921	4.7323	6.1413	7.6836	9.4421	–
$0.4 \rightarrow 0.5$	–	3.5118	4.9710	6.5082	8.1959	10.1293	–
$0.5 \rightarrow 0.6$	–	3.6333	5.2140	6.8826	8.7209	10.8373	–

Notes: Parameter values, unless stated otherwise: $R = 3.5\%$, $R_D = 2.5\%$, $K = 15$, $q = 8.5\%$, $\sigma = 0.3$, $R_C = 0.5\%$, and $\alpha = 0.1$. The values in the shaded areas are computed based on an approximate optimal loan rate of 4.6%. The corresponding results are confirmed by the validness of the second-order condition.

The results presented in Table 5 are based on Equation (10) where $A = \alpha$. The positive direct effect is observed from the second panel. This is because an increase in α makes loans less risky to grant, and hence decrease the bank's equity risk, ceteris paribus. The indirect effect is also negative in sign observed from the third panel. As mentioned in Table 4, an increase in α increases R_L. In response to this, the bank has an incentive to reduce the amount of loans it grants, and hence decrease the bank's equity risk. Overall, since the indirect effect reinforces the direct effect to give a negative response of σ_S to an increase in α, we state that an increase in the hedging diversification transaction decreases the bank's equity risk. Our result is consistent with the findings of Cebenoyan and Strahan [38]: swap hedging transaction activities help manage bank risk.

The consistent results of $\Delta SHP < 0$ evaluated at various optimal bank interest margins are obtained from the first panel of Table 6. We state that the swap hedging diversification is harmful to the bank. The direct effect observed from the second panel is negative because an increase in the swap diversification transaction directly increases the bank's net-obligation payments and hence the bank's equity return is decreased, ceteris paribus. The negative direct effect demonstrates that the efficiency loss from the swap diversification is positively related to the swap transaction. The indirect effect observed from the third panel is positive in sign. We can argue that the effect of the swap transaction on the efficiency gain is uncertain due to the fact that an increase in α decreases the bank's profit by $L(R_L)$ in every possible state. The indirect effect is insufficient to offset the direct effect to give an overall positive response of the efficiency loss to an increase in the swap transaction. Therefore, we suggest that the swap diversification transaction activities help manage bank equity return and risk, but have the incremental effect on efficiency loss. The former is largely supported by Cebenoyan and Strahan [38], while the latter is implicitly consistent with Keys et al. [39].

TABLE 8. Responsiveness of bank equity risk to government capital injection

	$(R_L\%, L)$						
θ	$(4.5, 200)$	$(4.6, 199)$	$(4.7, 197)$	$(4.8, 194)$	$(4.9, 190)$	$(5.0, 185)$	$(5.1, 179)$
	σ_S						
0.1	1.1829	1.1802	1.1766	1.1720	1.1662	1.1593	1.1510
0.2	1.1661	1.1634	1.1596	1.1548	1.1487	1.1414	1.1325
0.3	1.1494	1.1466	1.1427	1.1376	1.1313	1.1235	1.1141
0.4	1.1327	1.1299	1.1259	1.1206	1.1139	1.1057	1.0958
0.5	1.1162	1.1133	1.1091	1.1036	1.0966	1.0880	1.0776
0.6	1.0997	1.0967	1.0924	1.0867	1.0794	1.0704	1.0595
	$\partial\sigma_S/\partial\theta$: direct effect						
$0.1 \to 0.2$	−0.1678	−0.1684	−0.1698	−0.1720	−0.1753	−0.1795	−0.1850
$0.2 \to 0.3$	−0.1671	−0.1677	−0.1691	−0.1714	−0.1745	−0.1787	−0.1841
$0.3 \to 0.4$	−0.1665	−0.1670	−0.1684	−0.1706	−0.1737	−0.1779	−0.1831
$0.4 \to 0.5$	−0.1658	−0.1663	−0.1676	−0.1698	−0.1729	−0.1769	−0.1821
$0.5 \to 0.6$	−0.1650	−0.1655	−0.1668	−0.1690	−0.1720	−0.1760	−0.1810
	$(\partial\sigma_S/\partial R_L)(\partial R_L/\partial\theta)$: indirect effect (%)						
$0.1 \to 0.2$	–	−0.0845	−0.1546	−0.2511	−0.3825	−0.5632	–
$0.2 \to 0.3$	–	−0.0895	−0.1693	−0.2806	−0.4335	−0.6455	–
$0.3 \to 0.4$	–	−0.0947	−0.1847	−0.3118	−0.4881	−0.7342	–
$0.4 \to 0.5$	–	−0.1000	−0.2008	−0.3448	−0.5462	−0.8295	–
$0.5 \to 0.6$	–	−0.1054	−0.2176	−0.3796	−0.6080	−0.9315	–
	$d\sigma_S/d\theta$: total effect (%)						
$0.1 \to 0.2$	–	−16.9196	−17.1307	−17.4552	−17.9087	−18.5158	–
$0.2 \to 0.3$	–	−16.8613	−17.0799	−17.4158	−17.8861	−18.5182	–
$0.3 \to 0.4$	–	−16.7984	−17.0248	−17.3729	−17.8615	−18.5209	–
$0.4 \to 0.5$	–	−16.7308	−16.9654	−17.3265	−17.8348	−18.5240	–
$0.5 \to 0.6$	–	−16.6582	−16.9015	−17.2765	−17.8059	−18.5274	–

Notes: Parameter values, unless stated otherwise: $R = 3.5\%$, $R_D = 2.5\%$, $K = 15$, $q = 8.5\%$, $\sigma = 0.3$, $R_C = 0.5\%$, and $\alpha = 0.1$. The values in the shaded areas are computed based on an approximate optimal loan rate of 4.6%.

5.3. **Increases in government capital injection.** The findings based on Equations (9), (10), and (11) are summarized in Tables 7, 8, and 9, respectively, where $0.1 \leq A = \theta \leq 0.6$, $R_C = 0.5\%$, and $\alpha = 0.1$.

Based on the result of $\partial R_L/\partial\theta > 0$ observed from Table 7, we state that government capital injection leads to an increase in the optimal loan rate and a decrease in the volume of loans. The intuitive reason for this result is the following: government capital injection creates a link between both sides of the bank's balance sheet. As the government capital injection to the bank increases, the bank provides a return based on a larger equity capital base. One way the bank may attempt to augment its total returns is by shifting its investments to the liquid-asset market and away from its loan portfolio at an increased loan rate. Our result emphasizes the direct impact of government capital injection on loan volumes which is consistent with the regulatory bailout objective of making failure less likely. Our finding is supported by the argument of Berger and Bouwman [13]: public outcries for more bank capital tend to be greater after financial crises.

The results presented in Table 8 are based on Equation (10) where $A = \theta$. The negative direct effect is observed from the second panel. Intuitively, the negative direct effect

Table 9. Responsiveness of efficiency gain to government capital injection

	$(R_L\%, L)$						
θ	$(4.5, 200)$	$(4.6, 199)$	$(4.7, 197)$	$(4.8, 194)$	$(4.9, 190)$	$(5.0, 185)$	$(5.1, 179)$
	ΔSHP						
0.1	−1.8280	−1.8157	−1.7933	−1.7608	−1.7180	−1.6648	−1.6011
0.2	−1.8124	−1.7996	−1.7765	−1.7432	−1.6994	−1.6451	−1.5800
0.3	−1.7950	−1.7816	−1.7578	−1.7235	−1.6787	−1.6231	−1.5565
0.4	−1.7757	−1.7616	−1.7370	−1.7018	−1.6558	−1.5988	−1.5306
0.5	−1.7542	−1.7394	−1.7140	−1.6778	−1.6305	−1.5721	−1.5020
0.6	−1.7306	−1.7151	−1.6888	−1.6514	−1.6028	−1.5427	−1.4707
	$\partial\Delta SHP/\partial\theta$: direct effect						
$0.1 \to 0.2$	0.1556	0.1613	0.1681	0.1763	0.1859	0.1973	0.2108
$0.2 \to 0.3$	0.1741	0.1802	0.1876	0.1964	0.2070	0.2195	0.2345
$0.3 \to 0.4$	0.1937	0.2001	0.2081	0.2177	0.2292	0.2430	0.2595
$0.4 \to 0.5$	0.2143	0.2211	0.2296	0.2400	0.2525	0.2676	0.2857
$0.5 \to 0.6$	0.2359	0.2431	0.2522	0.2634	0.2770	0.2934	0.3132
	$(\partial\Delta SHP/\partial R_L)(\partial R_L/\partial\theta)$: indirect effect (%)						
$0.1 \to 0.2$	–	0.3877	0.9547	1.7671	2.8663	4.3236	–
$0.2 \to 0.3$	–	0.4206	1.0370	1.9286	3.1441	4.7678	–
$0.3 \to 0.4$	–	0.4563	1.1260	2.1028	3.4439	5.2486	–
$0.4 \to 0.5$	–	0.4950	1.2223	2.2909	3.7680	5.7702	–
$0.5 \to 0.6$	–	0.5369	1.3264	2.4942	4.1186	6.3367	–
	$d\Delta SHP/d\theta$: total effect						
$0.1 \to 0.2$	–	0.1652	0.1777	0.1940	0.2146	0.2405	–
$0.2 \to 0.3$	–	0.1844	0.1980	0.2157	0.2384	0.2672	–
$0.3 \to 0.4$	–	0.2047	0.2193	0.2387	0.2636	0.2955	–
$0.4 \to 0.5$	–	0.2261	0.2418	0.2629	0.2902	0.3253	–
$0.5 \to 0.6$	–	0.2485	0.2655	0.2883	0.3182	0.3567	–

Notes: Parameter values, unless stated otherwise: $R = 3.5\%$, $R_D = 2.5\%$, $K = 15$, $q = 8.5\%$, $\sigma = 0.3$, $R_C = 0.5\%$, and $\alpha = 0.1$. The values in the shaded areas are computed based on an approximate optimal loan rate of 4.6%.

demonstrates a decrease in the bank's equity risk due to an increase in the government capital injection, holding the optimal bank interest margin constant. This result is understood that an increase in the government capital injection provides a source of capital to the distressed bank, resulting in decreasing the bank's equity risk since liquidity shock is overcome ([3,24]). The negative indirect effect arises because an increase in the government capital injection increases in the optimal loan rate (as mentioned in Table 7), resulting in decreasing loans and thus decreasing the bank's equity risk. Overall, since the indirect effect reinforces the direct effect to give a negative response of σ_S to an increase in θ, we state that an increase in government capital injection decreases the bank's equity risk. This indicates that the government capital injection can stabilize the distressed bank, which is consistent with the findings of Bayazitova and Shivdasani [3].

The result of $\Delta SHP < 0$ is obtained from the first panel of Table 9. This means that the bank potentially harms from swap hedging diversification at a given level of government capital injection. The positive direct effect is observed from the second panel. This result indicates that the efficiency loss from loan portfolio hedging diversification is negatively related to government capital injection, ceteris paribus. The indirect effect is also positive in sign observed form the third panel. The indirect effect reinforces the direct effect to give an overall positive response of ΔSHP to an increase in θ. As can be seen from the result of $d\Delta SHP/d\theta > 0$ in the last panel, an increase in the government capital injection decreases the efficiency loss from diversification. Hence, it appears that the distressed bank may be taking advantage of the loss from swap diversification when the government capital injection increases. Government capital injection as such may capture a reduced loss efficiency to the distressed bank's extension of credit, yielding an increased return and a reduced equity risk for the bank. Our results are supported by Bayazitova and Shivdasani [3].

6. **Conclusions.** The goal of this paper is to explore the role played by loan portfolio hedging diversification transaction activities in a bank under government capital injection. In particular, this paper addresses the impacts of hedging and capital on bank performance and efficiency gain from hedging. On the positive side, our findings suggest that hedging and capital helps to enhance equity return with a corresponding reduced equity risk for the bank. On the negative side, we argue that hedging diversification is not guaranteed to produce efficiency gain; however, an increase in the government capital injection increases bank equity return, decreases bank equity risk, and decreases the efficiency loss from hedging diversification. Our analysis sheds light on the economic roles of hedging and government capital injection. One implication is that future theoretical exploration of the economic roles of hedging and government capital injection ought to pay attention to counterparty credit risk in the hedging activities as well as different means of government intervention when bank performance and safety are analyzed.

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