Does Trading in Derivatives Affect Bank Risk? The Canadian Evidence

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Abstract

We delineate the impact of derivatives trading on asset risk for Canadian banks over the period starting 1997 till the fallout of the bank crisis in 2007. In light of the remarkable resilience of Canadian banks in dodging the current financial turmoil, we investigate whether such bank stability is attributable to effective risk management through derivatives use. After imputing asset risk from bank stock prices based on the option-theoretic model of Merton (1974), we ascertain the links between the implied asset risk and derivatives use for trading and hedging purposes. Our findings reveal that not only bank risk increases with trading in derivatives, but increases also with derivatives reportedly used for hedging. This puzzling evidence is robust to different model specifications and alternative methods of estimations. Our new evidence is important in two ways. First, it casts doubt on the effectiveness of hedge accounting. Second, it shows that the use of derivatives by Canadian banks does not explain their envied soundness. We therefore conclude that prudent practices limiting original risk exposures remain fundamental for safeguarding a healthy financial system. This lesson from Canada is particularly relevant for China, given its developing financial infrastructure and extreme reliance on banks in providing financing to its economy.

Keywords: Bank risk, Option-theoretic, Implied volatility, Financial stability, Derivatives trading, Hedging,

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1. Introduction

The stability and safety of banks are among the top concerns of all financial authorities in the world. The recent turmoil in global capital markets triggered by the frail U. S. banks has clearly demonstrated the importance of maintaining a healthy banking system in the economy.

The Canadian banking industry has been highly regarded for its soundness (IMF, 2008; WEF, 2008), even with the fallout from the recent financial collapse in the U.S. and the close ties between the two economies. What explains such stability of the Canadian banks? Is it due to effective hedging and trading in derivatives, or simply because the original risks prior to any hedging are well controlled? Since derivatives – be they used for hedging or trading – are predominant in bank risk management, it is of paramount significance to gauge the role played by derivatives in affecting the riskiness of banks so as to better understand what constitutes prudent banking practices.

In a recent study, Minton, Stulz, and Williamson (2009) raise concern about the inability of US banks to use hedge accounting when hedging with credit derivatives and question about the general belief that the use of derivatives make banks sounder.

In this paper, we examine how derivatives trading by Canadian banks affect their aggregate risks, taking into consideration of both the banks' hedging and off-balance sheet activities. Our approach has two novel features. First, we distinguish between derivatives uses by banks for hedging and trading purposes. This distinction is crucial as we show that the effects on bank risk of derivatives use for the two purposes are different, and thus must be accounted for in empirical investigations. Second, we impute asset risk using an option-based algorithm. Since this implied measure encompasses the net effect on risk of all on- and off-balance sheet activities including derivatives used for hedging and trading, it is arguably the best proxy for bank risk.

Our study addresses a timely question as it provides an explanation to the resilience and soundness of the Canadian banking system especially in the light of the recent financial debacle. To our knowledge, it is the first study to examine how the use of derivatives through hedging and trading alters the risk of bank assets, and thus bank soundness within the Canadian context. Our surprising new evidence that derivatives engaged by banks for trading and hedging both increase the implied volatility of assets calls for more regulatory attention, as the *intent* of derivatives use may fail to prevent speculative behavior that would worsen bank risk, and thus, bank stability.

The rest of the paper proceeds as follows. Section 2 derives risk implications of derivatives used for trading and hedging. Section 3 outlines the data and describes our research design. Section 4 covers the empirical evidence and Section 5 concludes

2. The Theoretical Framework: Derivatives Uses by Banks

Owing to their business operations, banks are exposed to three broad categories of risks related to: interest rate, credit, and others. To manage these risks, banks can align and limit risk exposures with well-designed policies/procedures to exploit the covariations among the multidimensional risks within a bank – an approach called "coordinated risk management" by Schrand and Unal (1998). But more generally, banks use financial derivatives such as swaps, futures, options, and off-balance sheet items to offset potential losses from the various risk exposures – an approach well known as hedging.

However, banks also use derivatives for trading purposes. As opposed to hedging, when trading, banks offer derivative products to clients for them to manage their risks. In such cases, banks generate revenue through market-making as well as positioning and arbitrage.

The effects of derivatives on bank risk, however, are different when they are used for hedging vs. trading. With hedging, the variability in value of aggregate assets (i.e. the risk of a bank) is always reduced, since each hedge is taken to offset an existing position, whereas with trading, the risk effect is less clear. Individually, each trade in derivatives stands alone – without an opposite position to offset its loss or gain – which increases variability, and thus risk. In aggregate, however, given the many positions engaged by a bank in derivatives trading, there is no reason for the number and amount of short trades to be consistently larger or smaller than those of long trades, *unless* the dominant short or long positions are intentional bets on the future prices/rates, as exemplified by the infamous case of Barings. Thus, for trading purpose, a bank's net position in derivatives should oscillate between long and short. We use the following proposition to delineate the relative variability of bank risk when derivatives are used for hedging and trading purposes:

Proposition 1

While derivatives used for hedging reduce the asset risk of a bank, there are five possibilities as to the net impact of derivatives trading on bank risk:

i) trades become *effective hedge* and reduce risk, thus $Var(\tilde{w}_u) > Var(\tilde{w}_T)$;

ii) trades are similar to *under-hedge* and still mitigate risk, thus $Var(\tilde{w}_u) > Var(\tilde{w}_T)$;

iii) trades are similar to *over-hedge* and add risk, thus $Var(\tilde{w}_u) < Var(\tilde{w}_T)$;

iv) trades turn out to be *pure speculation* and increase risk, thus $Var(\tilde{w}_u) < Var(\tilde{w}_T)$;

v) trades are neutral in affecting risk, thus $Var(\tilde{w}_u) = Var(\tilde{w}_T)$.

where

Var denotes variability; $\tilde{w}_H$ is the value of a bank's aggregate assets when derivatives are used for *hedging*; $\tilde{w}_u$ is the value when *no* derivatives are used; and $\tilde{w}_T$ is the value when derivatives are used for *trading*.

Proof: See Appendix A.

Therefore, bank risk decreases when derivatives are used for hedging, whereas the risk either decreases or increases, or does not change when derivatives are used for trading. This difference between hedging and trading is fundamental and often overlooked. For example, it is commonly believed that involvements in derivatives makes banks riskier, and for this reason, banks in many countries are required to report their holdings of derivatives separately for hedging and trading purposes by conducting hedge accounting. Provided that the stringent rules for hedge accounting are followed such that banks classify properly their derivatives for hedging or trading, we can make inferences on how derivatives are actually being used by banks for controlling risk or generating profit, based on our imputed risk of bank assets.

Specifically, if derivatives are effectively used for mitigating risks, it should be reflected by a negative relationship between derivatives and asset risk; however, if derivatives are used for generating profits, their aggregate effect on risk of bank assets can be negative, positive, or null. This is the main hypothesis implied by Proposition 1 that can be tested, after we have extracted the asset risks of banks using the procedure described below.

Note that even a hedge can have a speculative component as market views – opinions on the future price/rate – can influence the formation of a hedging strategy, blurring thereby the distinction between hedging and trading. Whether the market actually perceives a bank's use of derivatives as hedging or speculating is thus an empirical issue and can be inferred from our estimated relationship between derivatives and asset risk. In addition to such inference, the fact that our procedure is able to ascertain how present/severe this speculative component is in banks' hedging activities constitutes strength of our study

3. Data and Research Design

3.1 *Sample Selection*

To investigate the impact of use of derivatives by Canadian banks on implied volatility of their assets we first manually compile data on the use of derivatives by the major six banks[1], over the period from 1997 to 2007. Our observations were taken quarterly at the release date of the banks' financial results. We restrict our analysis to this time frame because quarterly financial reports of banks published by the bank of Canada and the Office of Superintendent of Financial Institutions Canada (OSFIC) have been available electronically since 1997.

Our analysis addresses the impact of the use of derivatives on bank risk. To this end we regress bank's implied volatility of assets on bank's intent of using derivatives (hedging or trading) and on other control variables. More specifically, we estimate several specifications of the following cross-sectional, time-series model:

$$BANK_{i,t} = \alpha_0 + \sum \beta_i \times DUSE_{i,t} + \sum \lambda_i \times CONT_{i,t} + \varepsilon_{i,t} \qquad \text{---- Equitation (*)}$$

[1] The banking system in Canada is characterized by a small number of predominant banks with branches operating nationwide. Over the last two decades, the six largest banks have controlled about 90 percent of total bank assets in Canada, while the increasing foreign banks' presence has remained limited to less than 10 percent of bank assets. In order of market capitalization on the Toronto Stock Exchange as of December 2007, the "big six" Canadian commercial banks are: Royal Bank of Canada (RBC), Toronto-Dominion Bank (TD), Bank of Nova Scotia (Scotiabank), Bank of Montreal (BMO), Canadian Imperial Bank of Commerce (CIBC), and National Bank of Canada (National Bank).

where, $DUSE_{i,t}$ is the ratio of the value of derivatives contracts used for trading (or hedging) over the implied value assets (V_A). *CONT* is a set of bank-level control variables commonly used in bank hedging literature (e.g. Dai, 2009c). Namely we control for other off-balance sheet items intensity (i.e. ratio of the notional amount of other off-balance sheet items over imputed value of assets), financial leverage,[2] net interest margin,[3] non interest income,[4] and market-to-book value. We include these variables in our analysis to ensure that our results are not driven by alternative interpretation. $BRISK_{i,t}$ is the asset risk of bank "*i*" measured in quarter "*t*" (σ_A). Our measure of bank asset risk is the implied volatility of assets. To estimate the implied volatility assets we manually collect data on the value of the bank's equity (V_E), the volatility of the equity value (σ_E), the book value of the bank's liabilities (L), the time to maturity (T), the risk-free interest rate (r), and the derivatives position taken for hedging purposes (D_H) and for trading purposes (D_T). More details on the way we calculate bank risk are given in the next section.

3.2 *The Algorithm for Imputing Bank Risk: Implied Volatility of Bank Assets*

It is well recognized that the equity of a banking firm has an option nature (Merton, 1974). Thus, by making the same assumptions that are underlying the Black-Scholes-Merton

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[2] In Bloomberg, 'Financial leverage' is calculated using the following formula: (Avg. Total Assets)/ (Avg. Total Comm. Equity)
Total Equity = Share Capital & APIC + Retained Earnings; Avg. is the average of the beginning balance and ending balance.
[3] The formula for 'Net interest margin' in Bloomberg is as follows: (Net Interest Income)/(Average Earning Assets) * 100
Net Interest Income = Interest Income + Investment Income - Interest Expense; Earning Assets = Marketable Securities & ST Investments + Total Loans + Interbank Assets + LT Investments & LT Receivables; Net Interest Income is on a Taxable Equivalent basis, where applicable, for the banking format. Interbank Assets may include Securities Purchased with a Resell Agreement,; Total Loans = Total Advances to Customers
Average earning assets is the average of the most recent and prior-year balances.
Ratio is based on trailing 12 month net interest income.
[4] Data on Non-interest income obtained from Bloomberg is calculated as the sum of Trading Account Profits (Losses), Commissions & Fees Earned and Other Operating Income (Losses).

option pricing model, equity can be treated as a call option on the firm's assets with a strike price equal to the liabilities of the firm. The market value of the firm's equity and the book value of the firm's liabilities can then be used to calculate backwards to obtain the (unobservable) market value of the firm's assets as well as the (unobservable) risk of the assets.[5]

To use the Black-Scholes option pricing model, the following assumptions are made: a) the market has no transaction costs and no taxes; b) the banks have a single class of zero coupon debts; c) default only occurs if the market value of the assets is less than the value of the debt liabilities on the maturity date; d) the value of the banks' assets follows a stochastic process:

$$dV_A = (\mu_A - \delta_A)V_A dt + \sigma_A V_A dz \qquad \text{---- (1)}$$

where

V_A is the value of the bank's assets and dV_A is the change in the asset value over the time interval *dt*; μ_A is the asset value's growth rate; σ_A is the risk or volatility of the asset value; δ_A is the payout rate in percentage of asset value V_A, which "shrinks" V_A; and *dz* is a Wiener process, which describes random shock over time interval *dt*.

From these assumptions, it follows that the relationship between the market value of the equity and the market value of the assets is given by:

$$V_E = V_A e^{-\delta T} N(d_1) - De^{-rT} N(d_2) \qquad \text{---- (2)}$$

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[5] Although there are more sophisticated option models available, notably those using time-varying volatility, the original model of Black-Scholes remains the most basic and intuitive, and fits our primary motivation of using an option-theoretic approach to extracting the latent variables of asset value (*V*) and asset risk (σ_A). Studies adopting this approach include Ronn and Verma (1986), Vassalou and Xing (2004), Bharath & Shumway (2008), Dai (2009b), Dai (2009c), amongst others.

where

$$d_1 = \frac{\ln(V_A/D) + (r - \delta + \sigma_A^2/2)T}{\sigma_A\sqrt{T}} \qquad \text{---- (3)}$$

$$d_2 = d_1 - \sigma_A\sqrt{T} \qquad \text{---- (4)}$$

V_E is the market value of the bank's equity; δ is dividend yield on the bank's equity; D is the promised payment on the bank's liabilities; T is the time that the bank's liability is due; and r is the risk free interest rate.

As for the bank equity value, V_E, we can treat its evolution from two perspectives. On the one hand, we can consider V_E as behaving according to a stochastic process (just as the bank asset value):

$$dV_E = (\mu V_E - \delta)dt + \sigma_E V_E dz_E \qquad \text{---- (5)}$$

where

μ is the instantaneous expected growth rate of V_E; σ_E is the instantaneous volatility of equity return per unit time; and dz_E is a standard Weiner process.

On the other hand, we can formally write bank equity value V_E at any time point as a function of bank asset value V_A and time t:

$V_E = F(V_A, t)$.

Applying Itô's Lemma to the above relation, we get:

$$\begin{aligned} dV_E &= F_{V_A} dV_A + 0.5F_{V_A V_A}(dV_A)^2 + F_t dt \\ &= [0.5\sigma_A^2 V_A^2 F_{V_A V_A} + (\mu_A V_A - \delta_A)F_{V_A} + F_t]dt + \sigma_A V_A F_{V_A} dz \end{aligned} \qquad \text{---- (6)}$$

Since equations (5) and (6) both describe the dynamics of equity value, V_E, all the corresponding terms in the two equations must be the same. In particular, for the terms involving stochastic innovations:

$$\sigma_E V_E = \sigma_A V_A F_{V_A} \qquad \text{---- (7)}$$

Noting that F_{V_A} is calculated from equation (2):

$$F_{V_A} = \frac{\partial F}{\partial V_A} = \frac{\partial V_E}{\partial V_A} = e^{-\delta T} N(d_1)$$

Substituting this expression of F_{V_A} in equation (7), we obtain:

$$\sigma_E = \frac{V_A}{V_E} e^{-\delta T} N(d_1) \sigma_A \qquad \text{---- (8)}$$

The two equations, (2) and (8), are combined to solve for the two unknowns, V_A and σ_A, which are the asset value and asset risk of a bank.

Because the two equations represent a system of non-linear equations, the solutions require a numerical procedure such as the Newton-Raphson method to find simultaneously the values of V_A and σ_A that satisfies both equations.

For a system of non-linear equations, it can be shown that

$$X_{n+1} = X_n - J^{-1} F(X_n) \qquad \text{---- (9)}$$

where

X_{n+1} is a column vector with new approximations to the roots as elements; X_n is a column vector with old approximations to the roots as elements; F is a column vector with the functions in the system of non-linear equations as elements; J is the Jacobian matrix, which is a matrix of first-order partial derivatives of F ; and J^{-1} is the matrix inverse of J.

In correspondence to our system of non-linear equations, (2) and (8):

$$X_{n+1} = \begin{pmatrix} V_{A,n+1} \\ \sigma_{A,n+1} \end{pmatrix} \qquad \text{---- (10)}$$

$$X_n = \begin{pmatrix} V_{A,n} \\ \sigma_{A,n} \end{pmatrix} \qquad \text{---- (11)}$$

$$F = \begin{pmatrix} f_1 \\ f_2 \end{pmatrix} = \begin{pmatrix} V_A e^{-\delta T} N(d_1) - De^{-rT} N(d_2) - V_{E,input} \\ \frac{V_A}{V_E} N(d_1)\sigma_A - \sigma_{E,input} \end{pmatrix} \qquad \text{---- (12)}$$

and $$J = \begin{pmatrix} \frac{\partial f_1}{\partial V_A} & \frac{\partial f_1}{\partial \sigma_A} \\ \frac{\partial f_2}{\partial V_A} & \frac{\partial f_2}{\partial \sigma_A} \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix}, \quad J^{-1} = \frac{1}{|J|}\begin{pmatrix} d & -b \\ -c & a \end{pmatrix} = \frac{1}{ad - bc}\begin{pmatrix} d & -b \\ -c & a \end{pmatrix} \qquad \text{---- (13)}$$

where

$$a = \frac{\partial f_1}{\partial V_A} = e^{-\delta T} N(d_1)$$

$$b = \frac{\partial f_1}{\partial \sigma_A} = \frac{V_A e^{-\delta T} \sqrt{T} e^{-d_1^2/2}}{\sqrt{2\pi}}$$

$$c = \frac{\partial f_2}{\partial V_A} = \frac{\sigma_A}{V_E}\left[N(d_1) + \frac{N'(d_1)}{\sigma_A \sqrt{T}} \right] - \frac{V_A N(d_1)\sigma_A e^{-\delta T} N(d_1)}{V_E{}^2}$$

$$d = \frac{\partial f_2}{\partial \sigma_A} = \frac{V_A}{V_E}\left[N(d_1) + \sigma_A N'(d_1)\left(\frac{\sqrt{T}}{2} - \frac{\ln \frac{V_A}{D}}{\sigma_A^2 \sqrt{T}} - \frac{(r-\delta)\sqrt{T}}{\sigma_A^2} \right) \right] - \frac{{V_A}^2 N(d_1)\sigma_A e^{-\delta T} N'(d_1)\sqrt{T}}{{V_E}^2}$$

Derivations of these partial derivatives in the Jacobian matrix are found in Appendix B. Substituting equations (10) - (13) into equation (9), we get the iterative approximations for V_A and σ_A as follows:

$$V_{A,n+1} = V_{A,n} - \left(\frac{df_1 - bf_2}{ad - bc} \right) \quad \text{---- (14)}$$

$$\sigma_{A,n+1} = \sigma_{A,n} - \left(\frac{af_2 - cf_1}{ad - bc} \right) \quad \text{---- (15)}$$

To find the solutions for V_A and σ_A in the system of nonlinear equations (14) and (15), we use the programming tool Visual Basic Editor in Excel to implement a recursive computational procedure.

4. Empirical Results

Table 1 provides a summary on the types and purposes of derivatives used by Canadian banks[6]. Interest rate derivatives have by far the largest notional amount, representing about 68 percent of the total activity of derivatives use by Canadian banks. This is not surprising as interest rate swaps typically have the largest sizes of notional principals. Interestingly, the value of both interest rate derivatives and foreign exchange & golden represents, respectively, about 5 and 1.7 times the value of bank assets, suggesting that Canadian banks are actively involved

[6] Starting first quarter 2008, OFSI releases derivatives positions of banks classified along more categories and measured also in fair value. These modifications improve profiles of banks' derivatives positions, but given its availability over only one year, our data period ends at quarter one, 2008.

in derivatives activities. Equally important, and of particular interest to our study, derivatives contracts used for trading purposes represent the largest proportions of derivatives notional amounts across the three categories of derivatives. Such aggressive usage of derivatives for generating revenue rather than for managing risks seems surprising, given the stability of Canadian banks during the recent global banking and financial crisis.

Table 1 about here

Importantly, as shown in Proposition 1, while hedging derivatives can reduce bank asset risk, those used for trading purposes can increase, decrease, or not affect asset risk, and their net effect on asset risk is an empirical issue. This distinction, however, is not stressed enough in the literature and may explain the failure to find a clear effect of hedging on asset risk when total amount of derivatives (sum of hedge and trade) is used as a proxy for hedging.[7,8]

Table 2 about here

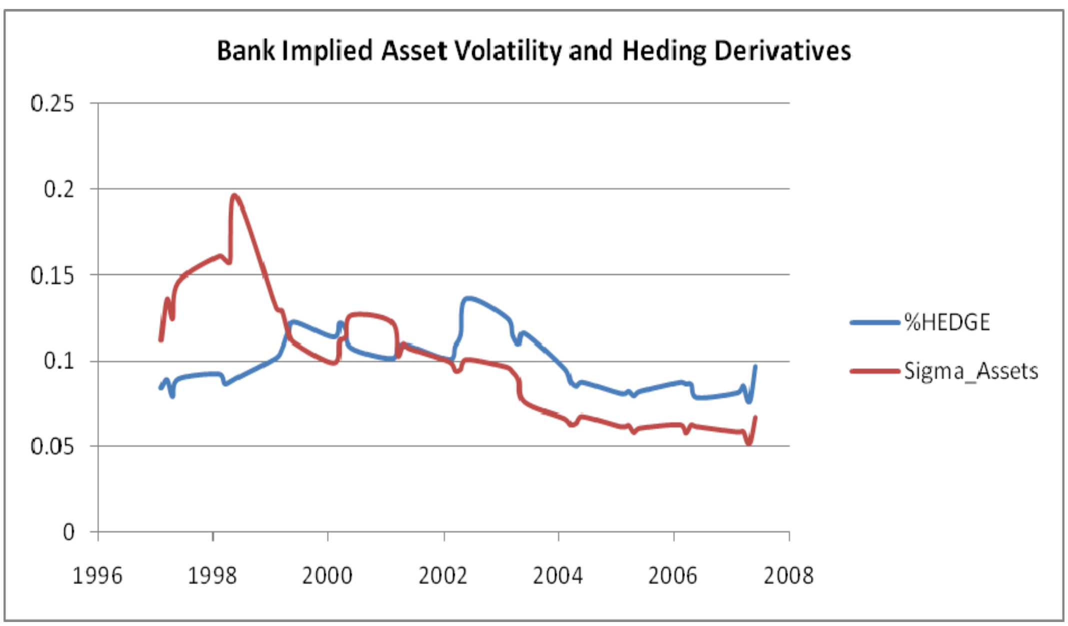
In Table 2, we report Pearson's correlation coefficients between the variables used in this study. Generally, the pairwise correlation coefficients among the control variables are low, especially between our test variables (Hedging Intensity and Trading Intensity). However, the high correlation between Other Off-Balance Sheet Intensity and Trading Intensity may raise some multicolineraity concerns. In order to ensure that multicolineraity will not be affecting our multivariate regression results, we conduct a multicollineraity test for our regressions. Namely, we use the approach provided by Belsley, Kuh, and Welsch (1980) to include in our

[7] See, for example, references in Clark et al. (2008).

[8] Results of the regression of the imputed asset risk on the total notional amount of derivatives, a commonly misused proxy for hedging in the literature, suggest that the notional amount has no significant impact on the risk of banks in the whole sample. At the bank-specific regressions its impact is however mixed. These results are unreported for the sake of brevity, but available from authors upon request.

multivariate regressions a *Variance Inflation Factor* (VIF) to detect multicollineraity, but we do not detect any multicollineraity problem in our multivariate analysis.

A surprising result arising from Table 2 comes from the positive correlation between hedging intensity and the imputed volatility of assets of Canadian banks, as one would naturally expect a negative impact of bank hedging activity on asset risk and formally illustrated in our Proposition 1. To shed further light on the relationship between hedging derivatives and bank risk we use graphical evidence. In Figure I, we plot the imputed volatility of assets (mean) and the amount derivatives used for hedging as percentage of the total amount of derivatives contract. Consistent with the correlation analysis, the positive relationship between the imputed volatility of Canadian banks and the amount of derivatives contracts used for hedging purposes is further confirmed.



Although the correlation and graph reveal preliminary and rather surprising evidence on the impact of hedging on bank risk, we perform a multivariate analysis to more rigorously examine the interaction between the different use of derivatives and bank risk. To this end, we estimate different specifications of Equation (*). All regressions are estimated with standard errors corrected for heteroscedasticity and with year indicator variables. Results are reported in Table 3. In interpreting the results, we primarily focus on the effects of MLS-related variables. In Model 1, our basic regression indicates a positive and significant impact of other off-balance sheet items, financial leverage and market-to-book value in explaining asset risk of Canadian banks. To some extent, the estimated coefficients of the control variables are consistent with previous studies (e.g. Hassan et al., 2002). In Model 2, we examine the impact of the intensity of derivatives trading. The estimated coefficient of our proxy for derivatives positions taken by banks for generating revenue is positive and significant at the level of 1%. This result indicates that, on average, the market perceives speculative behavior in bank trading derivatives, evident in an increase in bank's existing risk exposure. The other control variables show consistently the same sign and same level of significance.

Table 2 about here

Model 3 in Table 3 addresses the extent to which bank risk is altered by the use of derivatives for hedging purposes. The estimated coefficient of the hedging variable is positive and statistically significant at the 1% level. This evidence is rather mystifying as it runs against the economic intuition that hedging reduces risk, as illustrated in our Proposition 1. This evidence persists even in the complete model (Model 4) in which we control for derivatives used for trading. The fact that our proxy for hedging derivatives loads positively and significantly suggests derivatives contracts that are presumably booked under rules of hedge accounting as risk control instruments and reported to the regulatory authority as such have not the expected risk-reducing effect on bank assets. Two plausible explanations seem worthy of consideration for this perplexing evidence. The first plausible explanation stems from the fact that banks, in their capacity of dealers, may engage in large hedging derivatives contracts to manage the exposures induced by profit-driven derivatives positions (i.e. trading and other off-balance sheet activities). These offsetting positions (i.e. hedging positions) result in a significant increase in the *total* derivatives contracts (i.e. *notional* amount) reported by banks. It seems then that hedging positions are associated with some signaling effects about the speculative positions of the banks, which will likely enable the market to translate increased hedging positions into heightened asset risk. The second plausible explanation emerges from the difficulty of qualifying hedge derivatives for accounting hedge treatment (Yarish, 2003). Indeed, our "perplexing" evidence lends support, to some extent, to the contention of Minton, Stulz and Williamson (2009) that derivatives used for hedging can increase bank risk, evident in more volatile accounting earnings which eventually affect the market's perception of asset risk.[9]

Another interesting and equally plausible explanation stems from the ability of banks to effectively comply with hedge accounting. Do banks really use hedging derivatives for hedging? Do they over hedge because of their excessive speculative positions? These questions have yet to be fully assessed empirically.

To test the stability of our inferences to different methods of estimation we consider *mixed effects* modeling to estimate our regressions. Indeed, results in Table 3 are generated from pooled cross-sectional models, which do not control for the heterogeneity that stems from the functional form across the banks. Using firm-fixed effect that accounts for the heterogeneity among banks is more appropriate longitudinal model, because they allow implicit modeling of

[9] A similar argument is present by Hull (2007) p.29 that, in a competitive industry, the more you hedge, the more volatility your profit margin would be.

firm characteristics (observed and unobserved) that may influence the dependent variable (i.e. implied volatility of assets) in a firm-specific but time-invariant way. We re-estimate results of Table 3 by controlling for both bank and time fixed effects. We also use first-order autoregressive correlation specification (AR (1)) to control for the error correlation structure (e.g. the effect of autocorrelation in the residuals of the model). We opt for this robustness because observations within the same subject (i.e. bank) are correlated. Equally important, we produce White (1980) heteroskedasticity-consistent standard errors. Results are reported in Table 4.

Table 4 about here

Interestingly, the evidence in Table 4 shows that both hedging and trading derivatives load positively and significantly on the asset risk of Canadian banks. Evidence in Table 4 suggests that our results are robust to including bank-fixed effects and time-fixed effects, indicating that our prior findings (reported in Table 3) are not driven by banks' specific risk exposure and risk management.

5. Conclusion

We raise the issue of impact of bank *intent* in using derivatives on risk of major Canadian banks. To this end we employ the option-theoretic model to generate the volatility of bank assets as our proxy of bank risk. We contribute to the ongoing strand of studies on the impact of the use of derivatives by banks in two ways. First, we find that use of derivatives Canadian banks does not provide explanation to their envied soundness and resistance to the recent global financial debacle. Second, and most importantly, we bring new evidence by showing that hedging derivatives contracts *increase* significantly bank risk. This evidence is supported by both our univariate and multivariate analyses and is robust to use of various model specifications and different methods of estimation.

Two plausible explanations seem worthy of consideration for this *puzzling* evidence. First, hedging positions may be associated with some signaling effects about large speculative positions by banks. Second, the difficulty of qualifying hedge derivatives for hedge accounting treatment (Yarish, 2003) may shed some light on the positive impact of hedging derivatives on bank risk. Another interesting and equally plausible explanation stems from the ability of banks to effectively comply with rules of hedge accounting. Do banks really use derivatives for hedging? Do they over hedge because of their excessive speculative positions? Do our country-specific findings apply to other countries? These questions have yet to be fully assessed empirically.

References

Adam, T.R., 2002, "Do Firms Use Derivatives to Reduce their Dependence on External Capital Markets?" *European Finance Review* 6, 163-187.

Adam, T., S. Dasgupta, and S. Titman, 2004, "Financial Constraints, Competition, and Hedging in Industry Equilibrium," Hong Kong University of Science and Technology and University of Texas Working Paper.

Altman, E.I., 1968. Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *The Journal of Finance*, 23, 589-609.

Allayannis, G. and A. Mozumdar, 2000, "Cash Flow, Investment, and Hedging," University of Virginia and Virginia Tech Working Paper.

Allayannis, G. and E. Ofek, 2001, "Exchange Rate Exposure, Hedging, and the Use of Foreign Currency Derivatives," *Journal of International Money and Finance* 20, 273-296.

Allayannis, G. and J.P. Weston, 2001, "The Use of Foreign Currency Derivatives and Firm Market Value," *Review of Financial Studies* 14, 243-276.

Beaver, W.H., 1967. Market prices, financial ratios and the prediction of failure. *Journal of Accounting Research* 6, 179-192.

Berkman, H. and M.E. Bradbury, 1996, "Empirical Evidence on the Corporate Use of Derivatives," *Financial Management* 25, 5-13.

Bessembinder, H., 1991, "Forward Contracts and Firm Value: Investment Incentive and Contracting Effects," *Journal of Financial and Quantitative Analysis* 26, 519-532.

Bharath, B. & T. Shumway, (2008), "Forecasting Default with the Merton Distance to Default Model", *Review of Financial Studies* 21, 1339-1369

Black, F. and M. Scholes, 1973, "The Pricing of Options and Corporate Liabilities", *Journal of Political Economy*, 81, 637-54

Breeden, D. and S. Viswanathan, 1998, "Why Do Firms Hedge? An Asymmetric Information Model," Duke University Working Paper.

Brown, G.W., 2001, "Managing Foreign Exchange Risk with Derivatives," *Journal of Financial Economics* 60, 401-448.

Carter, D., D. Rogers, and B. Simkins, 2006, Does Hedging Affect Value? Evidence from the US Airline Industry, *Financial Management* 35, 53 – 86

Clark, J.A., Delisle, J., and Doran, J.S., 2008. Bank risk, implied volatility and bank derivative use: implications for future performance. Florida State University, Working Paper.

DaDalt, P., G.D. Gay, and J. Nam, 2002, "Asymmetric Information and Corporate Derivatives Use," *Journal of Futures Markets* 22, 241-267.

Dai, J., 2009a, "Financial Crisis and Government Bailouts: An Option-theoretic Approach", Journal of Financial Education, (forthcoming)

Dai, J., 2009b, "Discerning the Impact of Derivatives on Asset Risk", *Financial Markets, Institutions & Instruments* (forthcoming)

Dai, J., 2009c, "The Interaction between Hedging and Risk Taking, *Canadian Journal of Administrative Sciences* (submitted)

Deshmukh, S. and S.C. Vogt, 2005, "Investment, Cash Flow, and Corporate Hedging," *Journal of Corporate Finance* 11, 628-644.

Dolde, W., 1995, "Hedging, Leverage, and Primitive Risk," *Journal of Financial Engineering* 4, 187-216.

Flannery, M. and C. James, 1984, "The Effect of Interest Rate Changes on the Common Stock Returns of Financial Institutions," *Journal of Finance* 39, 1141-1153.

Froot, K., D. Scharfstein, and J. Stein, 1993, "Risk Management: Coordinating Investment and Financing Policies," *Journal of Finance* 48, 1629-1658

Gay, G.D. and J. Nam, 1998, "The Underinvestment Problem and Corporate Derivatives Use," *Financial Management* 27, 53-69.

Géczy, C., B.A. Minton, and C. Schrand, 1997, "Why Firms Use Currency Derivatives," *Journal of Finance* 52, 1323-1354.

Graham, J.R. and D.A. Rogers, 2002, "Do Firms Hedge in Response to Tax Incentives?" *Journal of Finance* 57, 815-839.

Guay, W. and S.P. Kothari, 2003, "How Much Do Firms Hedge with Derivatives?" *Journal of Financial Economics* 70, 423-461.

Hull, John, 2007, *Risk Management and Financial Institutions*, Pearson, Prentice Hall, New Jersey

Hassan, M. K., V. Lai, and Yu M-T, 2002, Market Discipline of Canadian Banks'Letters of Credit Activities: An Empirical Examination, *The Service Industries Journal* 22, 187–208

Haushalter, G.D., 2000, “Financing Policy, Basis Risk, and Corporate Hedging: Evidence from Oil and Gas Producers,” *Journal of Finance* 55, 107-152.

Jin, Y. and P. Jorion, 2006, “Firm Value and Hedging: Evidence from US Oil and Gas Producers,” *Journal of Finance* 61, 893-919

Belsley, D. A., Kuh, E., and Welsch R. E., 1980, *Regression Diagnostics*, Wiley, New York

Kennedy, P., 1992, *A Guide to Econometrics*, 3rd Ed, Cambridge, MA, MIT Press.

KMV Corporation, 2003, “Modeling Default Risk”, Moody’s KMV White Paper, at http://www.moodyskmv.com/research/whitepaper/ModelingDefaultRisk.pdf

Leland, H.E., 1998, “Agency Costs, Risk Management, and Capital Structure,” *Journal of Finance* 53, 1213-1243.

McDonald, R. L. 2006, *Derivatives Markets*, 2nd edition, Pearson Education, Inc., Boston, MA

Mello, A.S. and J.E. Parsons, 2000, “Hedging and Liquidity,” *Review of Financial Studies* 13, 127-153.

Mello, A.S. and M.E. Ruckes, 2004, “The Role of Hedging in Product Market Rivalry,” University of Wisconsin Working Paper.

Merton, R. 1974, “On the Pricing of Corporate Debt: The Risk Structure of Interest Rates”, *Journal of Finance* 29 (May), 449-470

Merton, R. 1992, *Continuous-Time Finance*, Blackwell Publishing, Malden, MA

Mian, S.L., 1996, “Evidence on Corporate Hedging Policy,” *Journal of Financial and Quantitative Analysis* 31, 419-439.

Minton, B., Stulz, R., and Williamson, R. 2009. How much do banks use credit derivatives to hedge loans? *Journal of Financial Services Research* 35, 1-31.

Myers, S.C. and N.S. Majluf, 1984, “Corporate Financing and Investment Decisions When Firms Have Information that Investors Do Not Have,” *Journal of Financial Economics* 13, 187-221.

Nance, D.R., C.W. Smith, Jr., and C.W. Smithson, 1993, “On the Determinants of Corporate Hedging,” *Journal of Finance* 48, 267-284.

Pantzalis, C., B.J. Simkins, and P. Laux, 2001, “Operational Hedges and the Foreign Exchange Exposure of US Multinational Corporations,” *Journal of International Business Studies* 32, 793-812.

Petersen, M. A., 2009, Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches, *Review of Financial Studies* 22, 435-480

Petersen, M.A. and S.R. Thiagarajan, 2000, "Risk Measurement and Hedging: With and Without Derivatives," *Financial Management* 29, 5-30.

Rogers, D.A., 2002, "Does Executive Portfolio Structure Affect Risk Management? CEO Risk-Taking Incentives and Corporate Derivatives Usage," *Journal of Banking and Finance* 26, 271-295.

Ronn and Verma (1986), "Pricing Risk-Adjusted Deposit Insurance: An Option-Based Model", *Journal of Finance* 41, 871- 895

Schaefer, S. and I. Strebulaev, 2008, "Structural models of credit risk are useful: Evidence from hedge ratios on corporate bonds", *Journal of Financial Economics* 90, 1-19

Schrand, C. and H. Unal, 1998, "Hedging and Coordinated Risk Management: Evidence from Thrift Conversions," *Journal of Finance* 53, 979-1013.

Smith, C.W., Jr. and R.M. Stulz, 1985, "The Determinants of Firms' Hedging Policies," *Journal of Financial and Quantitative Analysis* 20, 391-405.

Stulz, R.M., 1996, "Rethinking Risk Management," *Journal of Applied Corporate Finance* 9, 8-24.

Smith, C. and R. Stulz, 1985, "The determinants of firms' hedging policies", *Journal of Financial and Quantitative Analysis* 20, 391–405

Tufano, P. 1996, Who manages risk? An empirical examination of risk management practices in the gold mining industry, *Journal of Finance* 51, 1097-1137

Tufano, P., 1998, "Agency Costs of Corporate Risk Management," *Financial Management* 27, 67-77.

Vassalou and Xing (2004), "Default Risk in Equity Returns", *Journal of Finance* 59, 831-368

Warren, S., 2005, "Hedge Hog Southwest Air Sharpens Its Teeth," *Wall Street Journal*, May 19, C1.

White, H., 1984, "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test of Heteroskedasticity", *Econometrica* 48, 817–38.

Yarish, A., 2003, Mark-to-market accounting undercuts banks' loan hedging, *RMA Journal*.

Appendix A

Risk Effects of Derivatives Trading and Hedging

To formalize the different effects of hedging and trading on asset risk, suppose a bank holds a *long position* in a generic asset worth w_0 that is exposed to risk with future value in the next period equal to $\tilde{w}_u = w_0 \times \tilde{\varepsilon}$, where $\tilde{\varepsilon} \sim \mathrm{N}(1, \sigma_\varepsilon^2)$ represents the generic source of uncertainty or *original risk*. If this position is *unhedged*, its variability is $Var(\tilde{w}_u) = [w_0]^2 \sigma_\varepsilon^2$. When realization of the risk $\tilde{\varepsilon}$ is low (below average of 1), the unhedged position will incur a loss ($w_u < w_0$).

To cover this loss, the bank can take a *short hedge*, for example, sell futures with the *underlying risk* being the same as $\tilde{\varepsilon}$, so that if $\tilde{\varepsilon}$ is low the next period, the futures contracts will generate gain, since the bank (futures seller) will buy at low prevailing price and sell at high fixed price.[10]

The gain per futures contract = $(x_0 - \tilde{q}_1)$, i.e. the bank will purchase in spot market at low spot price $\tilde{q}_1$ and deliver/sell for high futures price x_0, thus realizing a profit of $(x_0 - \tilde{q}_1)$. The gain from a hedging position of selling *n* futures contracts = $n \times (x_0 - \tilde{q}_1)$. The end-of-period (t =1) total value of the hedged position is:

$$\underbrace{\tilde{w}_H}_{\substack{hedged\\position}} = \underbrace{w_0 \times \tilde{\varepsilon}}_{\substack{unhedged\\position}} + \underbrace{n \times (x_0 - \tilde{q}_1)}_{\substack{hedging\\position}} \qquad \text{---- (A-1)}$$

However, if the *n* futures contracts are taken for *trading* purposes, then the original long position, bundled with this trading position, gives:

$$\underbrace{\tilde{w}_T}_{\substack{bundled\\position}} = \underbrace{w_0 \times \tilde{\varepsilon}}_{\substack{original\\position}} + p \times \underbrace{n \times (x_0 - \tilde{q}_1)}_{\substack{short\\trading\ position}} + (1-p) \times \underbrace{n \times (\tilde{q}_1 - x_0)}_{\substack{long\\trading\ position}} \qquad \text{---- (A-2)}$$

[10] The underlying risk of the futures and the original risk to be hedged need not be exactly the same (i.e. perfectly positively correlated). All that is required is some degree of *correlation*.

where, p vary between 0 and 1, representing the propensity that the *trade in derivatives* turns out to be an *hedge* (p = 1, sell futures) reducing the risk of the bundled position and *speculation* (p = 0, buy futures) increasing the risk.

From equation (A-1):

$$Var(\widetilde{w}_H) = [w_0 - nx_0]^2 \sigma_\varepsilon^2 \qquad \text{---- (A-3)}$$

From equation (A-2):

$$Var(\widetilde{w}_T) = [w_0 + (1-2p)nx_0]^2 \sigma_\varepsilon^2 \qquad \text{---- (A-4)}$$

Depending on the value of the p, the risk effect of trading in derivatives on aggregate asset risk is delineated as following:

Scenario i) When p = 1, $Var(\widetilde{w}_T) = [w_0 - nx_0]^2 \sigma_\varepsilon^2 = Var(\widetilde{w}_H)$ is the smallest, trade becomes *effective hedge* and reduces risk.

Scenario ii) When 0.5 < p < 1, trade still mitigates risk, similar to *under-hedge*.

Scenario iii) When 0 < p < 0.5, trade still adds risk, similar to *over-hedge*.

Scenario iv) When p = 0, $Var(\widetilde{w}_T) = [w_0 + nx_0]^2 \sigma_\varepsilon^2$ is the largest, trade turns out to be *pure speculation* and increases risk.

Scenario iv) When p = 0.5, $Var(\widetilde{w}_T) = {w_0}^2 \sigma_\varepsilon^2 = Var(\widetilde{w}_u)$ trade turns out to be *neutral*.

In general, there is no reason for a bank to consistently take on the short or the long position when trading derivatives, thus trade should be independent of the original position. In such cases, p = 0.5, $Var(\widetilde{w}_T) = [w_0]^2 \sigma_\varepsilon^2 = Var(\widetilde{w}_u)$, that is, on average, trade in derivatives neither adds variability to nor reduces variability of the original position.

In summary, the following holds:

$$Var(\widetilde{w}_H) < Var(\widetilde{w}_u) = Var(\widetilde{w}_T) \qquad \text{---- (A-5)}$$

This shows that bank risk is reduced when derivatives are used for hedging and unaffected when used for trading.

If the bank originally holds a *short* position in the generic asset, then only the signs on the variables w_0, x_0, and $\tilde{q}_1$ in equations (A1) and (A2) change, and the conclusion on the relative variances of, $\tilde{w}_H$, $\tilde{w}_T$, and $\tilde{w}_u$ in equation (A5) continues to hold.

Appendix B

Derivation of the Partial Derivatives used in Imputing the Implied Asset Risk

The elements of the Jacobian matrix, the various partial derivatives represented by a, b, c and d, are calculated as follows:

$$f_1 = V_A e^{-\delta T} N(d_1) - De^{-rT} N(d_2) - V_{E,input}$$

where

$$d_1 = \frac{\ln \frac{V_A}{D} + \left(r - \delta + \frac{\sigma_A{}^2}{2} \right) T}{\sigma_A \sqrt{T}}$$

$$d_2 = d_1 - \sigma_A \sqrt{T}$$

and

$$N(x) = \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2} dx$$

is the cumulative standard normal distribution function, evaluated at point x. Note that the derivative of N, N', is equal to the standard normal probability density function

$$N'(x) = \phi(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$$

Because f_1 is the Black-Scholes option pricing formula with a numerical value ($- V_{E,input}$) added on, the partial derivatives of f_1 will be the same as the partial derivatives of Black-Scholes formula that are well known as the Greeks. Thus,

For a:

$\frac{\partial f_1}{\partial V_A}$ is equal to delta (Δ) = $e^{-\delta T} N(d_1)$

For b:

$\frac{\partial f_1}{\partial \sigma_A}$ is equal to vega (υ) = $\frac{V_A e^{-\delta T} \sqrt{T} e^{-d_1{}^2/2}}{\sqrt{2\pi}}$

The other elements of the Jacobian matrix are calculated manually by using Product rule: $(fg)' = f'g + fg'$ for all functions *f* and *g*, and Quotient rule: $\left(\frac{f}{g}\right)' = \frac{f'g - fg'}{g^2}$.

Thus, with $f_2 = \frac{V_A N(d_1)\sigma_A}{V_E} - \sigma_{E,input}$

For *c*:

$$\frac{\partial f_2}{\partial V_A} = \frac{V_E \frac{\partial [V_A N(d_1)]}{\partial V_A}\sigma_A - V_A N(d_1)\sigma_A \frac{\partial V_E}{\partial V_A}}{V_E{}^2} - 0$$

$$= \frac{V_E \sigma_A \left[N(d_1) + V_A N'(d_1)\frac{\partial d_1}{\partial V_A}\right] - V_A N(d_1)\sigma_A [e^{-\delta T} N(d_1)]}{V_E{}^2}$$

$$= \frac{V_E \sigma_A \left[N(d_1) + V_A N'(d_1)\frac{1}{V_A \sigma_A \sqrt{T}}\right] - V_A N(d_1)\sigma_A e^{-\delta T} N(d_1)}{V_E{}^2}$$

where $\frac{\partial V_E}{\partial V_A} = e^{-\delta T} N(d_1)$ is the delta (Δ) of a call option, and

$\frac{\partial d_1}{\partial V_A} = \frac{1}{V_A \sigma_A \sqrt{T}}$ by applying Chain rule: $\frac{\partial f(y)}{\partial x} = f'\frac{\partial y}{\partial x}$ and $\frac{\partial \ln y}{\partial x} = \frac{1}{y}\frac{\partial y}{\partial x}$ to d_1.

so,

$$\frac{\partial f_2}{V_A} = \frac{\sigma_A}{V_E}\left[N(d_1) + \frac{N'(d_1)}{\sigma_A \sqrt{T}}\right] - \frac{V_A N(d_1)\sigma_A e^{-\delta T} N(d_1)}{V_E{}^2}$$

For *d*:

$$\frac{\partial f_2}{\partial \sigma_A} = \frac{V_E V_A \frac{\partial [N(d_1)\sigma_A]}{\partial \sigma_A} - V_A N(d_1)\sigma_A \frac{\partial V_E}{\partial \sigma_A}}{V_E{}^2} - 0$$

$$= \frac{V_A}{V_E}\left[N(d_1) + \sigma_A N'(d_1)\frac{\partial d_1}{\partial \sigma_A}\right] - \frac{V_A N(d_1)\sigma_A [V_A e^{-\delta T} N'(d_1)\sqrt{T}]}{V_E{}^2}$$

where $\frac{\partial V_E}{\partial \sigma_A} = V_A e^{-\delta T} N'(d_1)\sqrt{T}$ is the vega (υ) of a call option, and

$$\frac{\partial d_1}{\partial \sigma_A} = \frac{\sigma_A \sqrt{T} \frac{\partial \left[\ln \frac{V_A}{D} + (r-\delta)T + \frac{1}{2}\sigma_A{}^2 T \right]}{\partial \sigma_A} - \left[\ln \frac{V_A}{D} + (r-\delta)T + \frac{1}{2}\sigma_A{}^2 T \right] \sqrt{T}}{\sigma_A{}^2 (\sqrt{T})^2}$$

$$= \frac{\sigma_A \sqrt{T} \sigma_A T - \left[\ln \frac{V_A}{D} + (r-\delta)T + \frac{1}{2}\sigma_A{}^2 T \right] \sqrt{T}}{\sigma_A{}^2 (\sqrt{T})^2}$$

$$= \frac{\sqrt{T}}{2} - \frac{\ln \frac{V_A}{D}}{\sigma_A{}^2 \sqrt{T}} - \frac{(r-\delta)\sqrt{T}}{\sigma_A{}^2}$$

so,

$$\frac{\partial f_2}{\partial \sigma_A} = \frac{V_A}{V_E} \left[N(d_1) + \sigma_A N'(d_1) \left(\frac{\sqrt{T}}{2} - \frac{\ln \frac{V_A}{D}}{\sigma_A{}^2 \sqrt{T}} - \frac{(r-\delta)\sqrt{T}}{\sigma_A{}^2} \right) \right] - \frac{V_A{}^2 N(d_1) \sigma_A e^{-\delta T} N'(d_1) \sqrt{T}}{V_E{}^2}$$

Table 1

Summary of Derivatives by Category and by Purpose

This table presents the composition of derivatives contracts held by all the Canadian banks over the years 1997-2007, measured in notional amount. As released by the OFSIC prior to the first quarter 2008, there are three categories of derivatives: Interest Rate Contracts, Foreign Exchange & Gold Contracts, and Others. Under each category, contracts are further assigned to two purposes: Trading or Other Than Trading (i.e. Hedging)

Ratio \ Category	Interest Rate Contracts	Foreign Exchange & Gold Contracts	Others
Total Derivatives in the Category / Total Assets	5.3715	1.71118	0.7027
Total Derivatives in the Category / Total Derivatives	0.6814	0.2543	0.0643
Derivatives for Trading in the Category / Total Derivatives in the Category	0.8801	0.9289	0.9648

Table 2

Correlations

This table reports Pearson's correlation coefficients for all the variables used in the regressions. Spearman correlations (unreported for brevity) are consistent with the Pearson correlations.

	Other Off-Balance Sheet Intensity	Hedging Intensity	Trading Intensity	Implied Volatility of Assets	Financial Leverage	Net Interest Margin	Non Interest Margin
Other Off-Balance Sheet Intensity	1						
Hedging Intensity	0.36	1					
Trading Intensity	0.62	0.20	1				
Implied Volatility of Assets	0.73	0.44	0.44	1			
Financial Leverage	0.34	0.12	0.25	0.19	1		
Net Interest Margin	0.56	0.23	0.33	0.42	-0.03	1	
Non Interest Margin	-0.16	-0.20	0.14	-0.14	0.19	-0.13	1
M/B Ratio	-0.37	-0.31	-0.18	-0.31	0.12	-0.24	0.57

Table 3

Assets Risk and Derivatives Usage by Banks

This table reports regression results for the effects of use of derivatives both for trading and hedging on the implied asset volatility of major Canadian banks over 1997-2007. All regressions are estimated with standard errors corrected for hetroscedasticity and with year indicator variables. The p-value is in parentheses below the estimated coefficients. The total number of quarterly observations is 264.
The dependent variable is the extracted risk of bank assets. As for independent variables, Trading Intensity is the notional amount of derivatives used for trading purposes divided by the extracted value of total assets; Hedge Intensity is the notional amount of derivatives used for hedging purposes scaled by total assets; Other off-BS Item is the other off-balance sheet items amount divided by total assets; Financial leverage is the long-term debt divided by the market value of equity; Net interest margin is the difference between interest income and income expenses divided by average earning assets; Non-interest income is the sum of trading account profits or losses, commissions and fees, and other operating incomes or losses, divided by total assets; M/B ratio is the ratio of market to book value.
*, **, *** denotes statistical significance at the 10%, 5%, or 1% level, respectively. Coefficients of intercepts are all significant at 1% level and not reported.

	Model 1	Model 2	Model 3	Model 4
Trading Intensity		4.85E-07*** (0.0008)		4.93E-07*** (0.0003)
Hedging Intensity			7.32E-06*** (<.0001)	7.35E-06*** (<.0001)
Other Off-Balance-Sheet Items	1.32E-05*** (0.0003)	1.14E-05*** (0.0023)	1.42E-05*** (<.0001)	1.23E-05*** (0.0001)
Financial Leverage	-0.00207*** (<.0001)	-0.0021*** (<.0001)	-0.00284*** (<.0001)	-0.00287*** (<.0001)
Net Interest Margin	-0.01115 (0.139)	-0.01239* (0.0914)	-0.01568** (0.0202)	-0.01696** (0.0115)
Non Interest Income	2.85E-06 (0.1911)	-7.01E-07 (0.7868)	3.23E-06* (0.0986)	-3.68E-07 (0.8753)
M/B Ratio	0.02157*** (<.0001)	0.02697*** (<.0001)	0.02537*** (<.0001)	0.03086*** (<.0001)
Adj. R-square	.7462	0.7555	0.8007	0.8107

Table 4

Fixed Effects Regressions

The table reports results of the fixed-effects regression models (mixed models) for the effects of use of derivatives on the implied asset volatility of major Canadian banks. All regressions are estimated with both bank-fixed and time-fixed effects and hetroscedasticity-robust standard errors. The p-value of the heteroscedasticity-consistent t-statistics is in parentheses below the estimated coefficients.

	Model 1	Model 2	Model 3	Model 4
Other Off-Balance-Sheet Items	0.000025** (0.0114)	0.000016 (0.1246)	0.000022*** (0.0046)	0.000013 (0.1521)
Trading Intensity		1.06E-06*** (<.0001)		9.82E-07*** (<.0001)
Hedging Intensity			7.92E-06*** (0.0038)	7.68E-06*** (0.0028)
Financial Leverage	-0.00029 (0.7300)	-0.00057 (0.4932)	-0.00064 (0.2961)	-0.00089 (0.1238)
Net Interest Margin	0.006988 (0.5876)	0.003299 (0.7847)	0.000668 (0.9531)	-0.00276 (0.7947)
Non Interest Margin	-9.94E-06** (0.0401)	-9.21E-06* (0.0676)	-8.79E-06* (0.0746)	-8.10E-06 (0.1294)
M/B Ratio	0.02293*** (0.0040)	0.02547*** (0.0025)	0.02727*** (0.0007)	0.02962*** (0.0002)
Time Fixed effects	Yes	Yes	Yes	Yes
Bank Fixed Effects	Yes	Yes	Yes	Yes