

## Comments on “Information about bank risk in options prices”

Michel Crouhy \*

*Canadian Imperial Bank of Commerce, Risk Management, 161 Bay Street, M5J 2S8 Toronto, Ontario,  
Canada*

---

The question being raised by the authors “Does implied volatility provide information about the risk of the bank?” (Swidler and Wilcox, 2002) is important and of great interest not only to the regulators, but also to investors and risk managers. Indeed, implied volatilities can be calculated every day, and if they provide unambiguous information about bank risk, then it is a useful variable to monitor. Therefore, as a risk manager, I have read this paper with great interest.

Eq. (1) in the paper constitutes the backbone of the argument developed by the authors:

$$\sigma_e^2 = \eta^2 \sigma_a^2 \quad (1)$$

where  $\sigma_e$  and  $\sigma_a$  denote the volatility of equity and asset returns, respectively, and  $\eta$  is the elasticity of equity price to asset value. Eq. (1) follows directly from Merton’s (1974) model where equity is a call option on the assets of the bank with the same maturity as the zero-coupon debt which constitutes the only debt financing of the bank, and with the strike price equal to the face value of the zero-coupon debt. Two comments come to mind when looking at Eq. (1).

Firstly, intuitively, if the volatility of the asset returns increases then the probability of default may indeed increase, keeping everything else constant. Why do I say may increase? If the volatility increases, this will increase the asset’s beta, assuming positive correlation with the market portfolio, and hence the expected return. An increase in the expected rate of return will, in turn, lower the probability of default. Hence, the net effect of an increase in the asset volatility on the risk of default is

---

\* Tel.: +1-416-594-7380; fax: +1-416-594-8528.

E-mail address: michel.crouhy@cibc.ca (M. Crouhy).

at least ambiguous. I would be tempted to relate this observation to the strategy followed by most North American banks which, over the past few years, have moved down market, investing in loans and bonds of lower credit quality but providing a better risk/return reward than investment grade facilities.

Secondly, we cannot observe the volatility of asset returns, but we can calculate the implied volatility of equity returns. However, the relation between the volatility of assets and the volatility of equity is itself ambiguous. Indeed, in a simple Merton (1974) framework, equity is a call option on the assets of the bank and an equity option is a compound option on the assets of the banks. The volatility of equity returns is then the volatility of asset returns time the elasticity of equity price to asset value – i.e. Eq. (1). For highly levered firms, which is precisely the case of banks, this elasticity is highly non-stationary (see Bensoussan et al., 1994). This problem, compounded by the fact that the capital structure of a bank is more complex than in Merton's model where the firm has only one liability – a zero-coupon bond, leads us to the conclusion that the relationship between the volatility of equity and the volatility of assets must be quite complex, and we should be careful in our interpretations of results generated from a simple model.

In addition, the asset volatility may not be constant and follow a complex process, such as Garch, which will be the source of estimation errors in the proposed model.

### 1. Implied volatility and leverage

The authors used regression (2) in the paper, taking as a proxy for asset risk of each bank the implied volatility of the S&P 100 index:

$$\ln(g_{t,i}) = \alpha_i + \beta_i \ln(g_{t,\text{VIX}}) + \varepsilon_{t,i} \quad (2)$$

where  $g_{t,i}$  denotes the equity implied volatility of bank  $i$  and  $g_{t,\text{VIX}}$  is the implied volatility of the S&P 100 index, both estimated at time  $t$ .

For each bank, each year denoted by  $k$ , the estimation of Eq. (2) will produce the elasticity estimate  $\hat{\beta}_{i,k}$ . These are matched with yearly equity/liability ratio i.e.  $(A_{i,k} - L_{i,k})/L_{i,k}$  where  $(A_{i,k} - L_{i,k})$  denotes bank  $i$ 's market value at the end of year  $k$ , and  $L_{i,k}$  is the book value of the bank's liabilities. Then, the authors run regression (3) for each bank  $i$ :

$$\hat{\beta}_{i,k} = \gamma_i + \delta_i \frac{A_{i,k} - L_{i,k}}{L_{i,k}} + u_{i,k}. \quad (3)$$

From the estimation results, reported in Table 5 in the paper, they conclude that there is a significant negative relation between the elasticity and the equity/liability ratio. In other words, bank leverage, or the inverse of the equity/liability ratio, raises the response of equity implied volatility to stock market volatility.

Besides the problem of using the implied volatility of the S&P 100 index as a proxy for asset risk of each bank, regression (2) gives biased estimates due to biases

Table 1  
Estimated relation of implied volatility elasticity to bank capitalization

	Constant	$(A - L)/L$	Adj. $R^2$	F-stat	p-value
1986–1997, annually					
<i>Implied volatility (Table 5 in the paper)</i>					
BAC	0.54 (5.37)	-0.30 (-1.64)	0.13	2.69	0.13
CCI	0.26 (5.49)	-0.24 (-3.00)	0.42	9.02	0.08
GWF	0.23 (11.57)	-0.10 (-2.86)	0.40	8.20	0.05
<i>Realized volatility</i>					
BAC	0.60 (2.91)	-0.36 (-0.72)	-0.05	0.52	0.49
CCI	0.42 (3.39)	0.05 (0.07)	-0.10	0.01	0.94
GWF	0.82 (3.12)	-2.59 (-1.91)	0.19	3.64	0.09
1986–1996, annually					
<i>Realized volatility</i>					
BAC	0.66 (2.04)	-0.56 (-0.62)	-0.07	0.38	0.55
CCI	0.30 (2.30)	1.23 (1.27)	0.06	1.61	0.24
GWF	0.13 (0.24)	1.57 (0.50)	-0.08	0.25	0.63

in both  $g_{t,i}$  and  $g_{t,VIX}$ .<sup>1</sup> Instead of using the ex ante implied volatility, we can use the ex post realized historical volatility in regression (2). To be consistent with the one-month implied volatility used by the authors I have computed the sample standard deviation of the daily returns over the next 22 business days – this is Eq. (4):

$$h_{t,i} = \sqrt{\frac{1}{22} \sum_{j=1}^{22} (r_{t+j,i} - \bar{r}_{t,i})^2} \quad \text{and} \quad h_{t,VIX} = \sqrt{\frac{1}{22} \sum_{j=1}^{22} (r_{t+j,VIX} - \bar{r}_{t,VIX})^2}. \quad (4)$$

We can now replace regression (2) by regression (5):

$$\ln(h_{t,i}) = \alpha_i + \hat{\beta}_i \ln(h_{t,VIX}) + \varepsilon_{t,i}. \quad (5)$$

Estimation results of regression (5) using both implied volatility and realized volatility are reported in Table 1.

When we use realized volatility, there is no longer any significant relationship between bank leverage and the response of equity volatility to stock market volatility.

<sup>1</sup> There is no consensus on whether implied volatility is an unbiased estimator of future volatility. Canina and Figlewski (1993) find that implied volatility for the S&P 100 index options is a poor forecast of subsequent realized volatility and does not incorporate information contained in recent observed volatility. However, this extreme result has been challenged by Christensen and Prabhala (1998) who find that implied volatility is a less biased forecast of future volatility than reported in previous studies when using volatility series for nonoverlapping data with exactly one implied and one realized volatility covering each time period in the sample. Recently, Poteshamn (2000) showed that most of the forecasting bias disappears when using Heston (1993) option pricing model to compute implied volatility of the S&P 500 options. In Heston's model volatility is stochastic and the model allows for a non-zero market price of volatility risk and a non-zero correlation between innovations to the level and volatility of the underlying asset.

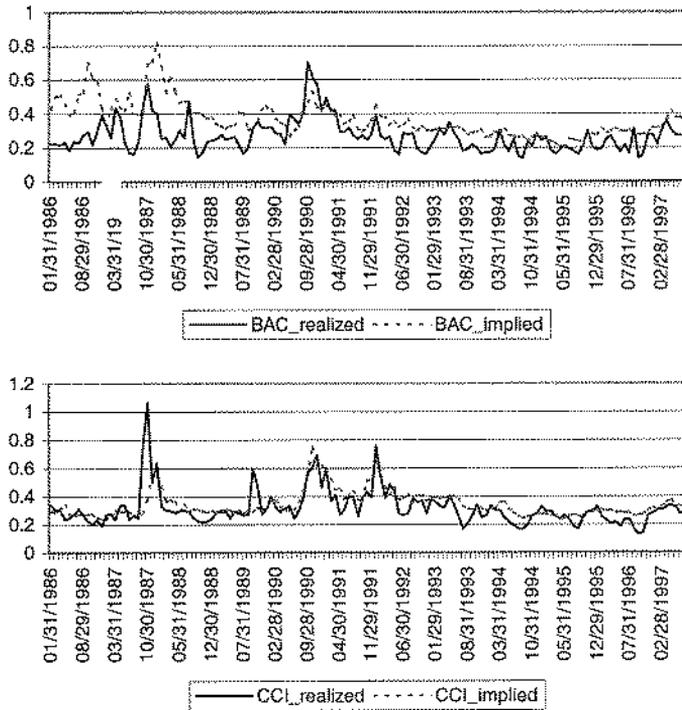


Fig. 1. Realized and implied volatilities for Bank of America (BAC) and Citicorp (CCI) 1986–1997, monthly.

Results are even worse when we eliminate the first 6 months of 1997 from the analysis, as a lot of merger activity took place during this period. For example, Great Western Financial (GWF) was the target in a take over attempt in the second quarter of 1997.

Fig. 1 shows that realized equity volatility is more volatile than implied volatility, and both can differ quite substantially at times.

## 2. Implied volatility, share price and sub-debt yield spreads

In Table 6 of the paper the authors report a negative relationship between implied volatility and the share price, using daily data. In Table 7 the authors report a positive correlation between implied volatility and the log of sub-debt yield spread, using monthly data.

But these results may be spurious as the time series are non-stationary. To test for non-stationarity we performed the augmented Dickey–Fuller (ADF) test for implied volatilities and the logs of share prices.<sup>2</sup> The results are reported in Table 2. For

<sup>2</sup> I could not perform the ADF test on the sub-debt yield spreads as the data was not available to me.

Table 2

Unit root test for logs of share prices and implied volatility 1986–1997, daily and monthly

	Log (BAC)	BACVOL	Log (CCI)	CCIVOL	Log (GWF)	GWVOL
Daily						
ADF test	0.04*	−6.11	0.76*	−6.82	0.03*	−6.85
Monthly						
ADF test	0.14*	−2.15*	3.97*	−2.89*	2.60*	−3.24*

\*Symbol indicates the series is non-stationary.

daily series, the logs of share prices are non-stationary. For monthly series, both implied volatilities and the logs of share prices are non-stationary. We suspect the sub-debt yield spread monthly data is also non-stationary.

These results are consistent with the casual observation of the data. In Fig. 2, we plot the implied volatilities and logs of share prices for BAC and CCI for the 1986–1997 period (Figs. 4 and 5 in the paper). From late 1994, it shows that the negative relation disappears between implied volatilities and the logs of share prices.

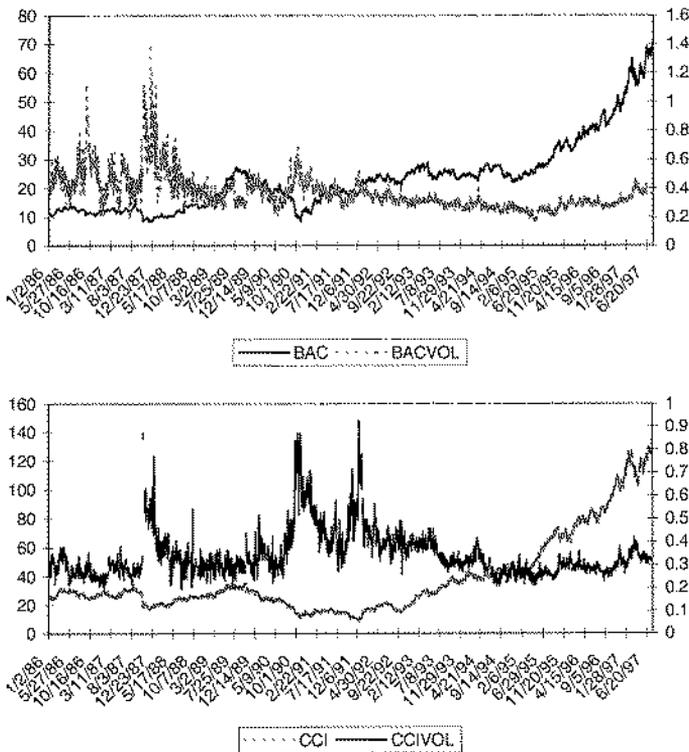


Fig. 2. Implied volatilities and logs of share prices for Bank of America (BAC) and Citicorp (CCI) 1986–1997, daily.

### **3. Conclusion**

The empirical results of this paper are interesting and in line with what one might expect. However, it is not clear if we observe changes in the implied volatility of equity that it implies necessarily changes in the volatility of the return on assets and changes in the risk of the bank, where we define risk in terms of the probability of insolvency.

I congratulate the authors on addressing an important topic and I look forward to reading their future work on this topic.

### **References**

- Canina, L., Figlewski, S., 1993. The information content of implied volatilities. *The Review of Financial Studies* 6 (3), 659–681.
- Bensoussan, A., Crouhy, M., Galai, D., 1994. Stochastic equity volatility related to the leverage effect I: Equity volatility behaviour. *Applied Mathematical Finance* 1 (1), 63–85.
- Christensen, B.J., Prabhala, N.R., 1998. The relationship between implied and realized volatility. *Journal of Financial Economics* 50, 125–150.
- Heston, S.L., 1993. A closed-form GARCH option valuation model. *Review of Financial Studies* 6, 327–344.
- Merton, R.C., 1974. On the pricing of corporate debt. *Journal of Finance* 28, 449–470.
- Potesman, A.M., Forecasting future volatility from option prices, Working paper.
- Swidler, S., Wilcox, J.A., 2002. Information about bank risk from options prices, *Journal of Banking and Finance* 26, this issue.