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MARKET INDICATORS, BANK FRAGILITY, AND INDIRECT MARKET DISCIPLINE

1. INTRODUCTION

From a supervisory perspective, the prices of securities issued by banks are interesting because they may complement or even be a substitute for traditional accounting data in assessing bank fragility. Market prices may efficiently summarise all available information in one convenient indicator. Moreover, market information is available at a very high frequency. Market information is also inherently more forward looking than accounting data. Hence, it has been proposed that supervisors use these signals as screening devices or inputs into early-warning models geared at identifying banks, which should be more closely scrutinised.[1]

This paper aims to ascertain the quality (that is, the predictive power and prediction errors) of two market indicators: the distance to default and the subordinated debt spread. Previous work has established that banks' market prices reflect contemporaneous information about bank risk in the United States and in Europe.[2] In our study, we first examine the theoretical properties of the indicators, namely, whether or not they are aligned with the conservative objectives of supervisors. We propose that in order to be aligned with these objectives, market indicators of bank fragility should be decreasing in earnings expectations, and increasing in earnings volatility and leverage. Using simple option-pricing theory, we show that the subordinated debt spread and the negative distance to default do indeed satisfy these properties.[3] We also find that the signal-to-noise ratio of subordinated debt spreads should be quite low far away from the default point of the bank. We then summarise the results obtained in Gropp, Vesala, and Vulpes (2002), which suggest that both indicators may have some usefulness in predicting bank fragility in the European Union (EU).

Based on two different econometric models—a logit model and a proportional hazard model—our results show that the negative distance to default predicts downgrades between six and eighteen months in advance and that the predictive properties are quite poor the closer to failure. In contrast, the predictive powers of spreads diminish beyond twelve months prior to a downgrade. The analysis also indicates that spreads are useful predictors only for banks, which are not implicitly insured against default, while the public safety net does not appear to affect the predictive power of the distance to default.

Furthermore, our results suggest that the distance to default provides some additional information relative to accounting variables, while this is not so for the spread. We also find support for the notion that the two indicators together have more discriminatory power in predicting failures than each does alone. In particular, "Type II" errors (a sound bank classified as weak) are reduced in a model that includes both market-based indicators. Similarly, market indicators reduce Type II errors relative to a model using accounting data alone. Hence, the use of market indicators may prevent supervisors from chasing false leads.

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The remainder of our paper is organised as follows. Section 2 briefly summarises the previous empirical literature. In Section 3, we present our main theoretical results, and in Section 4 we offer a summary of the empirical results obtained in Gropp, Vesala, and Vulpes (2002).

2. PREVIOUS LITERATURE

A number of recent papers studying U.S. banks are closely related to our work. Curry, Elmer, and Fissel (2001) find that stock prices exhibit a downward trend as many as two years before a supervisory CAMEL (Capital adequacy, Asset quality, Management, Earnings, and Liquidity) rating downgrade to 3, 4, or 5. Also, adding market variables to standard equations containing call report financial data improves their predictive power, especially for banks in the greatest financial distress. Evanoff and Wall (2001) find that accounting information has almost no predictive power for CAMEL and BOPEC (Bank subsidiaries, Other nonbank subsidiaries, Parent company, Earnings, and Capital adequacy) supervisory rating downgrades, but subordinated debt spreads perform only slightly better. Berger, Davies, and Flannery (2000) examine the relationship between supervisory information and a number of market indicators (rating changes, abnormal stock returns, and the proportion of equity owned by institutional investors and bank insiders). They find that supervisory assessments and bond ratings are at least partially able to predict each other, whereas supervisory assessments and equity indicators are not.

DeYoung et al. (2001) take the opposite approach and examine whether on-site examinations produce information that affects market prices. They find that this information is only gradually incorporated in banks' bond spreads, with particularly poor supervisory assessments reducing spreads and vice versa. They suggest that markets rely on supervisory discipline as a substitute for market discipline. Krainer and Lopez (forthcoming) investigate whether market prices contain additional information over accounting variables in predicting BOPEC rating changes. They answer this question in the affirmative, but caution that there is no improvement in out-of-sample forecasts. Interestingly, they find that debt market indicators have predictive power close to a downgrade only, while equity prices react much earlier, which is in line with the theoretical predictions obtained below. Furthermore, Bliss and Flannery (2002) suggest that the fact that market prices reflect bank risk does not necessarily imply that they discipline managers' behaviour ("monitoring" versus "influencing"). For a sample of U.S. banks, they find mixed evidence of significant influencing.

Our study focuses on equity prices in addition to spreads and highlights the importance of a careful selection of an appropriate equity market indicator. Signals based on equity prices have been considered ill suited for supervisors, because equityholders benefit from the upside gains that accrue from increased risk taking, leading to increased asset volatility. However, we show that the negative distance to default is increasing in asset volatility and thus is an appropriate risk indicator. There are several other aspects suggesting that equity prices, properly adjusted, may be attractive monitoring devices. First, there is broad consensus that the equity markets are quite efficient in processing available information. Second, while bond spreads are conceptually simple, their implementation is difficult. For example, Hancock and Kwast (2001) find that different bonds issued by the same U.S. bank may yield different estimates of the spread. In the European context, the construction of appropriate risk-free benchmarks, which is a necessary ingredient to the calculation of spreads, may also be difficult, especially for smaller countries.

3. SOME PROPERTIES OF THE DISTANCE TO DEFAULT AND THE SUBORDINATED DEBT SPREAD

For market indicators to yield useful information for supervisors, they must provide easily interpretable signals. We propose that for this to occur, at a minimum the indicator must give a signal of increased fragility: 1) if the bank's asset values decline, 2) if asset volatility increases, and 3) if leverage increases. In other words, a useful market indicator should be decreasing in earnings, and increasing in earnings volatility and leverage. It is well known that the firm's stock price generally does *not* satisfy criteria 2 and 3 (due to the call option implicit in equity) and hence is not considered a suitable indicator for supervisors. In this section, we use option-pricing theory in the valuation of equity and debt securities to demonstrate that the distance to default and the subordinated debt spread do satisfy the criteria.

For simplicity, we consider a bank liability structure that consists of equity (E) and junior subordinated debt (J) as well as some senior debt (I). At the maturity date (T), payments can only be made to the junior claimants if the full face value has been paid to the senior debtholders. Suppose that both classes of debt securities are discount bonds and that the promised payments (book values) are I and J, respectively. The total amount of debt liabilities then equals ($D = I + J$). To simplify the notation, we assume that time to maturity equals T at the time of valuation of the equity and debt securities. We further assume normal asset value diffusion and European option type (call for equity and put for debt). The market value of a debt instrument can then be expressed on the basis of the discounted value assuming no default risk and the value of a put option on the firm's assets (see Merton [1977] and Ron and Verma [1989]).[4]

3.1 Derivation of the Distance to Default

In the Black and Scholes (1973) model, the time path of the market value of assets follows a stochastic process of the form:[5]

$$(1) \qquad \ln V_A^T = \ln V_A + \left(r - \frac{\sigma_A^2}{2}\right)T + \sigma_A\sqrt{T}\varepsilon ,$$

which gives the asset value at time T (maturity of debt), given its current value, V_A, and its standard deviation, σ_A. The random component of the firm's return on assets is denoted by ε, which is standard normal. The risk-free rate is r. The current distance d from the default point (where $\ln V_A^T = \ln D$) can be expressed as:

$$(2) \quad d = \ln V_A^T - \ln D = \ln V_A + \left(r - \frac{\sigma_A^2}{2}\right)T + \sigma_A\sqrt{T}\varepsilon - \ln D \iff$$

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

That is, the distance to default, DD

$$(3') \qquad DD \equiv \frac{d}{\sigma_A\sqrt{T}} - \varepsilon = \frac{\ln\left(\frac{V_A}{D}\right) + \left(r - \frac{\sigma_A^2}{2}\right)T}{\sigma_A\sqrt{T}}$$

represents the number of standard deviations that the firm is from the default point. DD depends on V_A and σ_A. Though unobservable, these parameters can be calculated from the observable market value of equity capital (V_E) and the volatility of equity (σ_E) using the system of equations below:

$$(3'') \qquad V_E = V_A N(d1) - De^{-rT}N(d2)$$

$$\sigma_E = \left(\frac{V_A}{V_E}\right)N(d1)\sigma_A ,$$

$$d1 \equiv \frac{\ln\left(\frac{V_A}{D}\right) + \left(r + \frac{\sigma_A^2}{2}\right)T}{\sigma_A\sqrt{T}}$$

$$d2 \equiv d1 - \sigma_A\sqrt{T}.$$

In order to yield a fragility indicator, we consider the negative of the distance to default (-*DD*) for which the following result holds.

Result 1:

Given D, (-DD) is decreasing in V_A, *and increasing in* D/V_A *and* σ_A, *iff* $V_A > V_A'$, *where* $V_A' = De^{-(1/2\sigma^2 + r)T}$.

Proof:

Clearly, $\frac{\partial(-DD)}{\partial V_A} < 0$ *and* $\frac{\partial(-DD)}{\partial D/V_A} > 0$.

$$\frac{\partial(-DD)}{\partial \sigma_A} = +\frac{1}{2}\sqrt{T} + \sigma_A^{-2}T^{-1/2}\left(\ln\left(\frac{V_A}{D}\right) + rT\right) > 0,$$

iff $V_A > De^{-(1/2\sigma^2 + r)T}$.

Hence, (-*DD*) satisfies our minimum requirements for a useful indicator of bank fragility as long as the market value of assets is not less than total discounted future debt service. If asset values fall below this threshold, the distance to default may *decrease* with asset volatility. The empirical evidence reported later suggests that the usefulness of this indicator does decline for banks close to default (or at least in serious financial difficulty).

3.2 Derivation of the Subordinated Debt Spread

In determining the value of subordinated debt spreads, it is important to account for subordination explicitly, since the payoff profile of the subordinated debt is different from that of the senior debt. Following Black and Cox (1976), the market value of subordinated debt (V_J) can be derived as a difference between two senior debt securities with the face values of ($I + J$) and I, and respective market values of (V_{I+J}) and (V_I):

$$(4) \quad V_J(V_A, D, \sigma_A, T) = V_{I+J}(V_A, I+J, \sigma_A, T) - V_I(V_A, I, \sigma_A, T).$$

The value of the individual senior debt securities can be expressed using the standard Merton (1990) option-pricing formula. By letting L denote the leverage ratio, that is, $(I + J)/V_A$, where $D = I + J$, the value of the debt security $(I + J)$ equals:

$$(5) \quad V_{I+J} = (I+J)e^{-rT}\left(N(h_2(I+J)) + \frac{1}{Le^{-rT}}N(h_1(I+J))\right),$$

$$h_1(I+J) \equiv \frac{-1/2\,\sigma_A^2 T + \ln\left(\frac{(I+J)e^{-rT}}{V_A}\right)}{\sigma_A\sqrt{T}} ,$$

$$h_2(I+J) \equiv \frac{-1/2\,\sigma_A^2 T - \ln\left(\frac{(I+J)e^{-rT}}{V_A}\right)}{\sigma_A\sqrt{T}} .$$

The other senior security (I) is valued as:

$$V_I = Ie^{-rT}\left(N(h_2(I)) + \frac{V_A}{Ie^{-rT}}N(h_1(I))\right) ,$$

with $h_1(I)$ and $h_2(I)$ defined as in equation 5. Finally, the yield to maturity, $y(T)$, of subordinated debt is defined as:

$$(6) \quad e^{-y(T)T}J = V_J, \text{ i.e., } y(T) = -\frac{1}{T}ln\left(\frac{V_J}{J}\right) = -\frac{1}{T}ln\left(\frac{V_{I+J} - V_I}{J}\right),$$

and the spread over and above the risk-free yield to maturity of the subordinated debt (S) equals $y(T)$-$r(T)$. The way it is defined here, S is equivalent to a credit risk premium, in the absence of any liquidity premia. Based on equations 5 and 6, we obtain:

Result 2:

Given $D = I + J$, *S declines in* V_A *and increases in* D/V_A *and* σ_A ,

iff $V > V^* = [I(I+J)]^{1/2}e^{-(1/2\sigma^2 + r)T}$.

Proof:

$$\frac{\partial S}{\partial V_A} = \frac{\partial y(T)}{\partial V_A} = -\frac{J}{TV_J}\left[\frac{\partial V_{I+J}}{\partial V_A} - \frac{\partial V_I}{\partial V_A}\right].$$

Following Merton (1990), $\frac{\partial V_{I+J}}{\partial V_A} = N(h_1(I+J))$ *and* $\frac{\partial V_I}{\partial V_A} = N(h_1(I))$.

Thus, $\frac{\partial S}{\partial V_A} = -\frac{J}{TV_J}[N(h_1(I+J)) - N(h_1(I))]$. *The expression in the brackets is always positive because* $N(h_1(I+J)) \geq N(h_1(I))$.

Since J *and* V_J *are always positive,* $\frac{\partial S}{\partial V_A} < 0$.

Second, $\frac{\partial S}{\partial L} = -\frac{J}{TV_J}\left(\frac{\partial V_{I+J}}{\partial L}\right)$.

Since $\frac{\partial V_{I+J}}{\partial L} = -N(h_1(I+J))L^{-2} < 0$, $\frac{\partial S}{\partial L} > 0$.

Third, $\frac{\partial S}{\partial \sigma_A} = -\frac{J}{TV_J}\left(\frac{\partial V_J}{\partial \sigma_A}\right)$. *Thus, the sign of* $\frac{\partial S}{\partial \sigma_A}$ *is the opposite of the sign of* $\frac{\partial V_J}{\partial \sigma_A}$. *According to Black and Cox (1976, p. 360),* V_J *is a decreasing (increasing) function of* σ_A *for* V_A *greater than (less than) the point of inflection,* V_A^*. *Thus, for* $V_A > V_A^*$,

$\frac{\partial S}{\partial \sigma_A} > 0.$[6]

Result 2 implies that the spread signals an increase in bank fragility only as long as the value of bank assets covers both senior and junior debt. If the asset value falls below this threshold, the interests of junior claimants resemble those of equityholders.

3.3 Value of Insured Debt

Following Merton (1977), the value of subordinated debt can be expressed in terms of two “no-default-risk” values for the senior debt securities ($I + J$) and I and two put option values (with strike prices equal to the book values of debt).

For instance, $V_I = V_I e^{-y(T)T} = V_I^{RF} - V_{I,PO} =$ $V_I e^{-r(T)T} - V_I e^{-r(T)T}N(-h2(I))VN(-h1(I))$,

where $V_I^{RF} = Ie^{-r(T)T}$

denotes the no-default-risk value and V_{PO} the value of the put option. A put option represents the value of the limited liability, that is, the right of equityholders to walk away from their debts in exchange for handing over the firm’s assets to the creditors.

In the case of fully insured debt (such as insured deposits), the put option component disappears and the market value of the debt equals the no-default-risk value (and S is zero). The put option value also represents the value of the deposit insurance guarantee, since by guaranteeing the debt the guarantor has in fact issued the put option on the assets (see Merton [1977]). Hence, the deposit insurance value (V_{PO}) could also be used as a bank fragility indicator (see Bongini, Laeven, and Majnoni [2002]) with the same characteristics as the market value of debt-based indicators. In case the explicit safety net is restricted, while the implicit safety net is perceived to be unrestricted, the value of the put option is also zero, since the debtholders would not face the risk of having to take over the assets of the bank.

3.4 Relationship between the Spread and the Distance to Default

Further note that the indicators may differ with respect to the strength of their reaction to a shock moving the bank closer to the default point. Based on the standard Black and Cox (1976) model, the spread is a convex and decreasing function of V_A for $V_A > V_A^*$ and would remain close to zero and rather stable for large changes in V. A significant reaction of the spread would only be measurable close to the default point.[7] Unless the bank is quite close to default, for S the signal-to-noise ratio may be quite low. The distance to default, by contrast, should react to adverse shocks even when default is still remote.

4. EMPIRICAL RESULTS FROM EU BANKS

Gropp, Vesala, and Vulpes (2002) test whether the two indicators do in fact have predictive power for bank fragility in a sample of EU banks. In the absence of bank failures and internal supervisory ratings in Europe, they measure bank fragility as a downgrade to C or below in the Fitch/IBCA individual rating of the bank. The Fitch/IBCA individual rating measures the quality of the bank, explicitly excluding the safety net—that is, the likelihood that the bank would receive support, either from official sources or from a parent. They find that in virtually all cases, a downgrade to C or below is associated with some eventual restructuring of the bank or with some public intervention within a year. The authors compile a sample of eighty-four banks, for which they have sufficient data to calculate the distance to default, and fifty-nine banks, for which they can calculate the subordinated debt spread. Of the eighty-four banks in the equity sample, twenty-six were downgraded to C or below during the sample period of 1990-2001. In the bond sample, there were twenty-two such downgrades.[8]

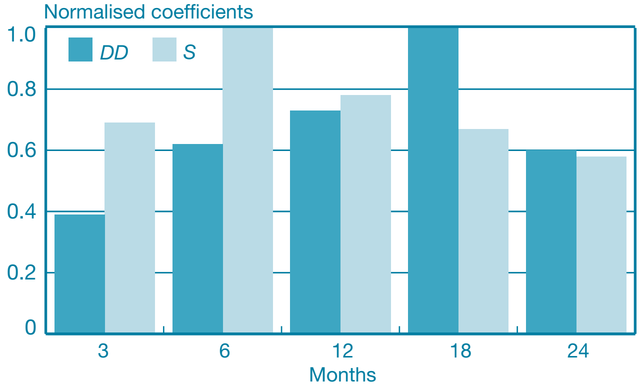
The authors estimate logit models with horizons of three, six, twelve, eighteen, and twenty-four months, as well as a proportional hazard model. First, they test for unconditional predictive ability of the two indicators.[9] They find that the negative distance to default has significant predictive ability of a downgrade up to eighteen months ahead.[10] The spread predicts downgrades only if the sample excludes: 1) U.K. banks (U.K. banks have significantly higher spreads relative to banks of equal quality in continental Europe)[11] and 2) banks that are likely to be covered by the public safety net. The likelihood of support is measured by the Fitch/IBCA support rating, which indicates the likelihood of public or parent bank support on a scale of 1 to 4. The predictive ability of the negative distance to default is unaffected by the safety net, suggesting that equityholders assign a low probability of being rescued along with debtholders in case of bank default. All of these results are in line with the predictions of the theoretical analysis presented above.

Chart 1 shows the patterns of the predictive ability of the two indicators. It presents the coefficients from the logit estimation, with the largest coefficient normalised to 1 (normalising reveals where the indicators reach maximum predictive power). The results confirm that spreads only have predictive ability shortly before the downgrade, whereas negative distances to default indicate problems with much longer lead times. As we argue above, we attribute the poorer predictive ability of the spread further away from the downgrade to the poor signal-to-noise ratio as long as the bank is very far away from serious difficulties.

Chart 2 plots the proportion of "Type I" and "Type II" classification errors for the two indicators. Both indicators predict downgrades accurately 60 and 80 percent of the time. For example, Chart 1 shows that the spread's predictive power seems greatest six months ahead of the downgrade. At that horizon, spreads predict with slightly more than 60 percent

CHART 1

Logit Results

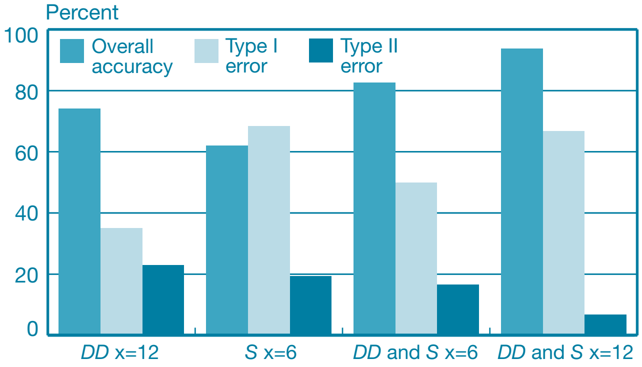


Source: Gropp, Vesala, and Vulpes (2002).

Notes: Coefficients are from a standard logit model, with the maximum normalised to 1. *DD* is the negative distance to default; *S* is the spread of subordinated debt relative to a government bond; "time to default" measures the time until a downgrade in the Fitch/IBCA individual rating to C or below.

CHART 2

Classification Accuracy Logit Models



Source: Gropp, Vesala, and Vulpes (2002).

Note: *DD* is the negative distance to default; *S* is the spread of subordinated debt relative to a government bond; x measures the time until a downgrade in the Fitch/IBCA individual rating to C or below.

accuracy. The negative distance to default predicts with slightly more than 70 percent accuracy twelve months before the downgrade.[12] The superior performance of the negative distance to default reflects fewer Type I errors, meaning that it does a better job of picking up downgrades correctly ("false negatives"). The Type II error, which reflects "false positives," that is, cases in which the indicator signaled "downgrade" and no downgrade followed, is around 20 percent for both indicators.

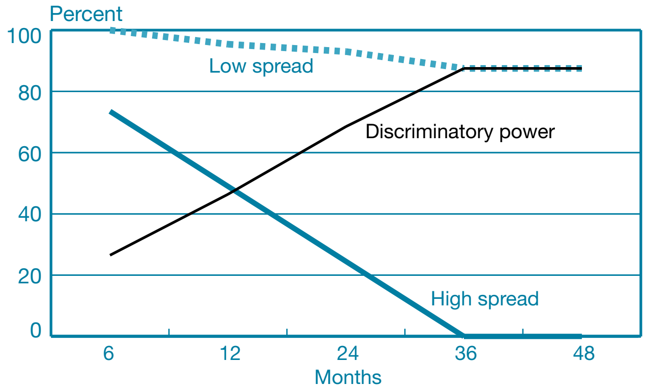
The different performance of the two indicators at varying horizons suggests that using both indicators may be better than using just one or the other. At the six-month horizon, the combined indicators have an overall accuracy of more than 80 percent; at the twelve-month horizon, the overall accuracy improves to more than 90 percent. The improved predictive ability reflects the contribution of the negative distance to default at longer horizons and yields a reduction in Type II errors to less than 10 percent.

We also examine classification accuracy by using a proportional hazard model. In such a model, what matters is whether the indicator adds information over time. Chart 3 plots the probability of survival for a bank with a high spread, the probability of survival for a bank with a low spread, and the difference between the two ("discriminatory power"). The discriminatory power increases over time, from slightly more than 20 percent after six months to more than 80 percent after thirty-six months. After thirty-six months, the spread tends to add little new information, because all banks with a high spread had been downgraded by then. The patterns for the distance to default look substantially different (Chart 4). The distance to default has little discriminatory power for twenty-four months. After that, it slowly increases to 25 percent. Because of their higher volatility, distances to default have to be observed much longer than spreads do in order to extract meaningful information.

Chart 5 summarises the comparison in Gropp, Vesala, and Vulpes (2002) of the predictive ability of market indicators and accounting information. Using an imaginary CAMEL rating constructed for each bank from publicly available data, they find that the CAMEL rating alone identifies downgrades twelve months ahead with 78 percent accuracy. Adding spreads increases accuracy to 82 percent, while adding spreads and the

Chart 3

Classification Accuracy and Discriminatory Power of Proportional Hazard Model, Spreads

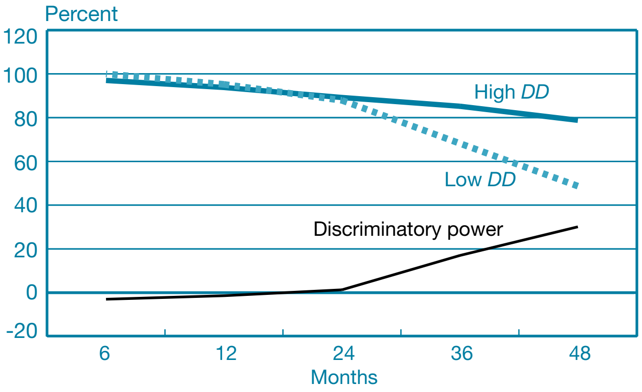


Source: Gropp, Vesala, and Vulpes (2002).

Notes: A high spread is defined as more than 98 basis points; a low spread is less than 98 basis points relative to the comparable government bond yield. The sample excludes U.K. banks.

Chart 4

Classification Accuracy and Discriminatory Power of Proportional Hazard Model, Distance to Default



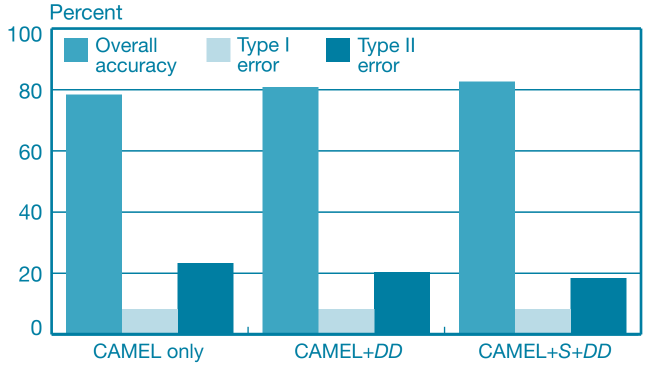
Source: Gropp, Vesala, and Vulpes (2002).

Note: Low distance to default (*DD*) is defined as less than 3.2 standard deviations from the default point; high *DD* is more than 3.2 standard deviations from the default point.

Chart 5

Classification Accuracy CAMEL Ratings, Spread and Distance to Default, Logit Results

Twelve-Month Horizon



Source: Gropp, Vesala, and Vulpes (2002).

Notes: A "Type I" error is defined as a misclassified downgrade (classified by the model as a no downgrade); a "Type II" error is defined as a misclassified nondowngrade (a bank that was not downgraded was classified as a downgrade). *DD* is negative distance to default; *S* is spread; CAMEL is Capital adequacy, Asset quality, Management, Earnings, and Liquidity (of banks).

negative distance to default raises accuracy to 84 percent. The marginal improvement from the market indicators is entirely due to a reduction in Type II errors. Even if the gain in accuracy is small, the benefit to supervisors from avoiding false warnings may be quite valuable.

5. CONCLUDING REMARKS

This paper examines the theoretical properties of various debt and equity indicators as signals of bank fragility. We demonstrate that the negative distance to default and the subordinated debt spread satisfy the minimal requirements of a useful indicator: both signal increased fragility as bank asset values decline and as asset volatility and leverage rise. We show that the distance to default should be informative even when default is remote, whereas the signal in spreads should be low when default is far off (due to the payoff structure of subordinated debt). To the extent that subordinated debtholders are covered by a safety net, the signal from subordinated debt spreads is weakened.

We also summarise Gropp, Vesala, and Vulpes' (2002) empirical tests of these properties for a sample of European banks. The results support using both indicators to detect future bank fragility. The distance to default predicts downgrades between six and eighteen months in advance, but its predictive properties are poor when failure is close. In contrast, the spread's predictive powers are poor when failure is far off, but improve as failure approaches. Spreads are *not* useful for banks that *are* implicitly covered by a government safety net, but the safety net does not seem to reduce the predictive power of the distance to default. Moreover, both indicators provide additional information relative to accounting data alone in the case of distance to default and little or no extra information in the case of spreads. Furthermore, proportional hazard models suggest that the distance to default needs to be monitored longer before the signal becomes reliable. These models are preferable to logit models because they waste less information. Forecasts from hazard models are also shown to improve with the length of the monitoring period. The two indicators together have more discriminatory power in predicting failures than each does alone. Finally, our analysis of classification errors indicates that the main value of market indicators is to reduce Type II (false positive) errors.

ENDNOTES

1. The use of market indicators by supervisors is commonly referred to as "indirect market discipline." This is in addition to the direct discipline that markets may impose upon banks (see, for example, Board of Governors of the Federal Reserve System [1999]).

2. Numerous studies relate U.S. secondary bond and/or stock market data to bank risk: Hand, Holthausen, and Leftwich (1992), Flannery and Sorescu (1996), Docking, Hirschey, and Jones (1997), Jagtiani, Kaufman, and Lemieux (2000), and Flannery (1998, 2001). In addition, Morgan and Stiroh (2001) relate U.S. primary bond market data to bank risk, Sironi (2003) relates European primary bond market data to bank risk, and Gropp and Richards (2001) relate European secondary bond and equity market data to bank risk. With few exceptions, all studies tend to find a significant relationship between market prices and risk, although risk and market prices are measured in different ways and the methodologies may differ substantially.

3. This is in contrast to simple stock prices, for example, which are increasing in earnings, increasing in earnings volatility, and increasing in leverage.

4. This result may not be robust to different (and possibly more plausible) distributional assumptions, for example, based on bounded returns (Bliss 2000); more complex liability structures; or under different option types, such as barrier options (Bergman, Grundy, and Weiner 1996). The analysis also relies on the idea that asset risk can be measured by asset variance, which seems to be relatively uncontested, while alternative approaches have also been proposed (for example, Harrison and Kreps [1979]).

5. See KMV Corporation (1999) for a similar derivation and more ample discussions.

6. Note that $V^* < V'$ as long as there is some junior debt outstanding.

7. Bruche (2001) shows that the "hockey-stick" shape of the spread as a function of V can become more pronounced when one introduces into the basic pricing model asymmetric information and investors' coordination failure.

8. For more details on the sample, see Gropp, Vesala, and Vulpes (2002).

9. To facilitate comparisons across indicators, the regressions use -*DD* rather than *DD*.

10. Interestingly, Gropp, Vesala, and Vulpes (2002) find no significant predictive ability of the distance to default three months before the downgrade. They propose a number of possible explanations for this surprising finding, including a reduction in equity volatility right before the downgrade and greater heterogeneity in the volatility before the downgrade (resulting in a noisier signal).

11. This is not a new finding. Sironi (2003) reaches the same conclusion using a sample of primary spreads.

12. It turns out that this rate is somewhat better than at eighteen months before the downgrade.

REFERENCES

Berger, A. N., S. M. Davies, and M. J. Flannery. 2000. "Comparing Market and Supervisory Assessments of Bank Performance: Who Knows What When?" JOURNAL OF MONEY, CREDIT, AND BANKING 32, no. 3, part 2 (August): 641-67.

Bergman, Y. Z., B. Grundy, and Z. Weiner. 1996. "General Properties of Option Prices." JOURNAL OF FINANCE 51, no. 5 (December): 1573-1610.

Black, F., and J. C. Cox. 1976. "Valuing Corporate Securities: Some Effects of Bond Indenture Provisions." JOURNAL OF FINANCE 31, no. 2 (May): 351-67.

Black, F., and M. Scholes. 1973. "The Pricing of Options and Corporate Liabilities." JOURNAL OF POLITICAL ECONOMY 81, no. 3 (May/June): 637-54.

Bliss, R. R. 2000. "The Pitfalls in Inferring Risk from Financial Market Data." Unpublished paper, Federal Reserve Bank of Chicago, December.

Bliss, R., and M. J. Flannery. 2002. "Market Discipline in the Governance of U.S. Bank Holding Companies: Monitoring versus Influencing." EUROPEAN FINANCE REVIEW 6, no. 3: 361-95.

Board of Governors of the Federal Reserve System. 1999. "Using Subordinated Debt as an Instrument of Market Discipline." Federal Reserve System Study Group on Subordinated Notes and Debentures. STAFF STUDIES no. 172, December.

Bongini, P., L. Laeven, and G. Majnoni. 2002. "How Good Is the Market at Assessing Bank Fragility? A Horse Race between Different Indicators." JOURNAL OF BANKING AND FINANCE 26, no. 5 (May): 1011-28.

Bruche, M. 2001. "Bond Pricing with Co-ordination Failure: Implications for the Use of Spreads as an Indicator of Financial Health." Unpublished paper, European Central Bank.

Curry, T., P. Elmer, and G. Fissel. 2001."Regulator Use of Market Data to Improve the Identification of Bank Financial Distress." Unpublished paper, Federal Deposit Insurance Corporation.

DeYoung, R., M. J. Flannery, W. W. Lang, and S. M. Sorescu. 2001. "The Information Content of Bank Exam Ratings and Subordinated Debt Prices." JOURNAL OF MONEY, CREDIT, AND BANKING 33, no. 4 (November): 900-25.

Docking, D., M. Hirschey, and E. Jones. 2000. "Reaction of Bank Stock Prices to Loan-Loss Reserve Announcements." REVIEW OF QUANTITATIVE FINANCE AND ACCOUNTING 15, no. 3 (November): 277-97.

Evanoff, D., and L. Wall. 2001. "Sub-debt Yield Spreads as Bank Risk Measures." JOURNAL OF FINANCIAL SERVICES RESEARCH 20, no. 2-3 (October): 121-45.

Flannery, M. J. 1998. "Using Market Information in Prudential Bank Supervision: A Review of the U.S. Empirical Evidence." JOURNAL OF MONEY, CREDIT, AND BANKING 30, no. 3 (August): 273-305.

———. 2001. "The Faces of 'Market Discipline.'" JOURNAL OF FINANCIAL SERVICES RESEARCH 20, no. 2-3 (October/December): 107-19.

Flannery, M. J., and S. M. Sorescu. 1996. "Evidence of Bank Market Discipline in Subordinated Debenture Yields: 1983-1991." JOURNAL OF FINANCE 51, no. 4 (September): 1347-77.

Gropp, R., and A. Richards. 2001. "Rating Agency Actions and the Pricing of Debt and Equity of European Banks: What Can We Infer about Private Sector Monitoring of Bank Soundness?" ECONOMIC NOTES 30, no. 3 (November): 373-98.

Gropp, R., J. Vesala, and G. Vulpes. 2002. "Equity and Bond Market Signals as Leading Indicators of Bank Fragility." European Central Bank Working Paper no. 150, June.

Hancock, D., and M. L. Kwast. 2001. "Using Subordinated Debt to Monitor Bank Holding Companies: Is It Feasible?" JOURNAL OF FINANCIAL SERVICES RESEARCH 20, no. 2-3 (October/December): 147-87.

Hand, J., R. Holthausen, and R. Leftwich. 1992. "The Effect of Bond Rating Agency Announcements on Bond and Stock Prices." JOURNAL OF FINANCE 47, no. 2 (June): 733-52.

Harrison, J., and D. Kreps. 1979. "Call Options and the Risk of Underlying Securities." JOURNAL OF FINANCIAL ECONOMICS 13: 425-34.

Jagtiani, J., G. Kaufman, and C. Lemieux. 2000. "Do Markets Discipline Banks and Bank Holding Companies? Evidence from Debt Pricing." Federal Reserve Bank of Chicago Emerging Issues Series, no. S&R-99-3R, June.

REFERENCES (CONTINUED)

KMV Corporation. 1999. MODELLING RISK. San Francisco, Calif.: KMV Corporation.

Krainer, J., and J. Lopez. Forthcoming. “Forecasting Bank Supervisory Ratings Using Securities Market Information.” JOURNAL OF MONEY, CREDIT, AND BANKING.

Merton, R. 1977. “An Analytic Derivation of the Cost of Deposit Insurance and Loan Guarantees: An Application of Modern Option Pricing Theory.” JOURNAL OF BANKING AND FINANCE 1: 3-11.

———. 1990. CONTINUOUS TIME FINANCE. Oxford: Blackwell.

Morgan, D. P., and K. J. Stiroh. 2001. “Market Discipline of Banks: The Asset Test.” JOURNAL OF FINANCIAL SERVICES RESEARCH 20, no. 2-3 (October/December): 195-208.

Ron, E., and A. Verma. 1989. “Risk-Based Capital Adequacy Standards for a Sample of Forty-Three Major Banks.” JOURNAL OF BANKING AND FINANCE 13, no. 1 (March): 21-9.

Sironi, A. 2003. “Testing for Market Discipline in the European Banking Industry: Evidence from Subordinated Debt Issues.” JOURNAL OF MONEY, CREDIT, AND BANKING 35, no. 3 (June): 443-72.