Latin American credit ratings, the New Basel Capital Accord and portfolio risk

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RESUMO

Os bancos comerciais são obrigados a manter um montante de capital que varia com o risco percebido dos ativos do banco. A regra do capital baseado no risco inicialmente introduzida pelo Bank for International Settlements em 1988 está sendo revista. Este estudo oferece uma análise empírica de pesos propostos para o risco de capital para uma amostra de ativos globais. Nós aplicamos uma metodologia baseada em difusão para avaliar o "value-at-risk" (VaR) de uma carteira de títulos de renda fixa comparável àqueles atualmente emitidos, e que provavelmente serão emitidos no futuro próximo, por empresas na América Latina. Este trabalho utiliza um modelo de simulação para avaliar os riscos de mercado, básico e de crédito, que são correlacionados tanto para títulos individuais como para uma carteira de títulos de qualidade inicial de crédito similar. A taxa de juro ou risco de mercado é relativamente mais importante para títulos de alta qualidade (high-grade) emitidos por companhias fortes nos países desenvolvidos. O risco básico e o risco de crédito são mais importantes para empresas de países cujas dívidas soberanas são classificadas como "lower medium-grade" e "low-grade"

Palavras-chave: instituições financeiras, mercado financeiro internacional, política governamental e regulação, métodos econométricos e estatísticos, política de financiamento

ABSTRACT

Commercial banks are required by regulation to maintain capital that varies with the perceived risk of banking assets. The risk-based capital rule initially introduced by the Bank for International Settlements in 1988 is under revision. This study provides an empirical analysis of proposed capital risk-weights for a sample of global assets. We apply a diffusion-based methodology for assessing the value-at-risk (VaR) of a portfolio of fixed-income securities comparable to those now issued and likely to be issued for the foreseeable future by firms in Latin America. This is accomplished by simultaneously simulating both the future environment in which financial instruments will be valued and the credit rating of specific firms. This paper applies a simulation model to assess correlated market, basis and credit risk for both individual bonds and a portfolio of bonds of similar initial credit quality. Interest rate or market risk is relatively more important for high-grade bonds issued by strong companies from developed countries. Basis risk and credit risk are more important for companies from countries whose sovereign debt is rated lower medium-grade and low-grade.

Key words: Financial institutions, international financial markets, governmental policy and regulation, econometrics and statistical methods, and financing policy.

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Introduction

Sovereign countries issue debt securities in the international and global financial markets to obtain foreign currency reserves, balance fiscal deficits, and provide funds to support investment in public infrastructure related to utilities, roads, water and other projects deemed worthwhile. Private companies also borrow funds internationally to repay maturing debt obligations, and obtain funds to support strategic growth. Financial institutions and international development agencies, similar to corporations, issue securities globally to augment domestic funds raised from depositors and local investors. The international financial market has grown in excess of 15 percent per year during the last decade. The rapid expansion reflects the willingness of creditors to invest funds internationally to achieve higher returns and/or reduce risk relative to that possible from domestic alternatives. The growth also reflects the desire of debtors to tap markets at a lower rate and/or obtain funds with a more advantageous financial structure than available domestically.

Countries, companies and banks from Latin America have been active issuers of international debt. Most debt issued by Latin American countries, banks and corporations is rated "medium-grade" or "low-grade." Lower quality debt exposes investors to more credit risk than high-grade issues. The Bank for International Settlements recently released *The New Basel Capital Accord;* the accord will require banks investing in debt to back more risky assets with additional equity capital than currently dictated. This article evaluates by way of a mathematical simulation the individual and portfolio risks of bonds comparable to those issued internationally by Latin American corporate entities. The applied quantitative analysis simultaneously evaluates the consequence of credit, market and basis risk exposure relative to recently promulgated regulatory standards. The standards vary by credit quality; hence the analysis evaluates bonds by stratified credit quality similar to those encountered in Latin America. The analysis does not attempt to create an efficient portfolio, which would provide an interesting economic issue to study. Rather, we focus on whether the *New Basel Capital Accord* will require banks to set aside too much, too little, or an appropriate amount of equity capital? The answer will affect the ability of Latin American entities to borrow funds with desirable repayment attributes and attractive interest rates. The following section describes the growth, structure and risk profile of international debt in relationship to the *New Basel Capital Accord.* The descriptive material provides the context needed to understand the later application of applied economic techniques.

The international debt market and risk

International Debt - The international financial market expanded from approximately US $1 trillion in 1990 to US $6 trillion as of 2001. Approximately 95 percent of the global funds

raised are from the long-term capital market (i.e., maturity greater than one year) with only five percent from the short-term money market. Although individual bonds range from a maturity of one year to 40 years or more, the typical international bond ranges in term from five to ten years. Banks issue about one-half of the global debt with the remainder split among corporate, governmental and international development agency borrowers. Debtors from developed countries issue almost 80 percent of the global and international securities while offshore issuers account for eight percent, developing countries issue seven percent, and the remaining six percent are from international development agencies. About 70 percent of international debt is structured with an interest rate that is fixed while approximately 25 percent is issued with a floating-rate structure and four percent is issued on a zero-coupon basis. Almost 90 percent of international debt is denominated in US dollars, Japanese yen and the Eurozone's euro with the rest structured among a wide variety of other currencies. (Bank for International Settlements, 2000; Handorf, W. and Amira, K., 1999)

Although debt issued by Latin American borrowers only comprises 3.5 percent of all international debt as of 2000, sovereign bonds from Latin American countries comprise about eleven percent of the governmental debt market. Argentina, Brazil and Mexico alone account for nine percent of international governmental bonds outstanding. The simulation evaluates the risk exposure of bonds common to the global financial markets and Latin American debtors.

Credit Ratings and Sovereign Default Risk - Independent rating agencies, such as Moody's Investors Service and Standard & Poors, evaluate the likelihood investors will suffer a loss due to default by a sovereign or corporate issuer. The credit loss reflects both the probability of default and the recovery rate, if any, as a result of default. Table 1 provides a brief explanation of letter grades assigned by Moody's Investors Service. The agencies assign lower credit ratings to countries that are perceived to exhibit more political, economic and transfer risks for investors

Many bank regulatory authorities promulgate prudential rules related to the rating of either sovereign or corporate debt. Table 2 illustrates the global distribution of long-term, sovereign, foreign currency denominated debt ratings assigned by Moody's as of 2000. Most country debt is rated between "Aaa" and "B." In many cases, banks may only invest in high-grade ("Aaa and Aa") and medium-grade ("A and Baa") debt. The *New Basel Capital Accord* recommends different credit-risk weights for sovereign and corporate debt based on a standardized capital approach. Table 3 reviews the recommended credit-risk weights that range from 0 percent to 150 percent. Most bank regulatory authorities require their financial institutions to maintain capital at least equal to 8% of risk-weighted assets to be adequately capitalized. Capital must exceed 10% of risk-weighted assets to be well capitalized. Therefore, to be well-capital-

ized, a bank would need no capital against a sovereign Eurozone bond ("Aaa-rated" with 0 percent weight), 2 percent capital against a China bond ("A-rated" with 20 percent weight), 5 percent capital against an El Salvador or Mexican security ("Baa-rated" with 50 percent weight), 10 percent capital against a bond issued by Costa Rica ("Ba-rated" with 100 percent weight), and 15 percent capital for investment in a bond issued by Argentina ("Ca-rated" with 150 percent weight).

Table 1
Credit Rating Definitions by Moody's Investor Service

Letter Rating	Explanation
Aaa	Best quality
Aa	High quality
A	Upper medium grade
Baa	Medium grade
Ba	Possesses speculative elements
B	Generally lacks characteristics of a desirable security
Caa	Poor standing; may be in default
Ca	Highly speculative; often in default
C	Lowest grade; extremely poor prospects

Table 2
Sovereign Long-term, Foreign Currency Debt Ratings (2000)

Rating	Percent of Countries Based on Moody's Rating
Aaa	16%
Aa	11
A	10
Baa	22
Ba	17
B	20
Caa	4
TOTAL	100%

Table 3
Risk-based Capital Weights for Standardized Approach
from *New Basel Capital Accord

Rating	Sovereign	Corporate
Aaa	0%	20%
Aa	0%	20%
A	20%	50%
Baa	50%	100%
Ba	100%	100%
B	100%	150%
Caa	150%	150%

* Bank for International Settlements, 2001.

Table 4 compares the credit rating of the bonds issued by Latin American countries to the rest of the world. Debt of countries outside Latin America is equally divided among high-grade ("Aaa and Aa"), medium-grade ("A and Baa") and low-grade categories ("Ba, B, Caa and lower"). By contrast, about 75 percent of Latin American sovereign debt is rated low-grade as of 2000 and only 25 percent is judged to be investment quality. The difference in credit quality between Latin America and the rest of the countries whose debt has been rated by Moody's is statistically significant (chi-square test @ 1% confidence level). Latin American sovereign debt will be assigned risk weights of 50 percent, 100 percent and 150 percent based on the *New Basel Capital Accord.*

Table 4
Relative Credit Ratings of Latin American and Rest of World (2000)
(Percent Distribution)

Sector	High-grade (Aaa/Aa)	Medium-grade (A/Baa)	Low-grade (Ba/B/Caa)
World	33.3%	33.3%	33.3%
Latin American	0.0%	26.3%	73.7%

Corporate Credit Ratings and Default Risk - Debt issued by corporations is also evaluated by the credit rating agencies. Typically, the long-term, foreign currency credit rating assigned a corporation is no higher than a similar rating accorded the firm's country of residence. Risk factors facing a country - political, economic or transfer - will also plague a company.

The *New Basel Capital Accord* concurs with the assessment by the independent rating agencies and indicates,

> "*No claim on an unrated corporate may be given a risk weight preferential to that assigned its sovereign of incorporation. In countries where corporates have higher default rates, supervisory authorities should increase the standard risk weight for unrated claims where they judge that a higher risk weight is warranted by the overall default experience in their jurisdiction.* (Bank for International Settlements, 2001)

The highest credit rating assigned a Latin American country by Moody's as of 2000 is "Baa" to include Chile, El Salvador, Mexico, Panama and Uruguay. Consequently, no corporation - rated or unrated - would likely qualify with an individual corporate rating above "Baa." As illustrated by Table 3, lower medium-grade and upper low-grade corporate debt is 100 percent risk-weighted for bank capital purposes while debt rated "Ba" is assigned a risk weight of 100 percent, and a security rated "B" or lower is assigned a 150 percent risk weight.

Empirical studies suggest that rating agencies evaluate financial factors related to repayment of debt and/or the likelihood of default, assess legal covenants that may enhance recovery as a result of default, and determine the quality of management in relationship to the industry and business cycle. Key financial and legal factors leading to a lower corporate rating include: low or negative profitability and operating cash flow, high utilization of debt, no collateral, and junior or subordinated status. (Merton, R., 1974) Debt is rated when issued and subject to subsequent upgrades and/or downgrades as new information becomes available that affects the probability of default or recovery given default.

Investors in corporate debt, even securities with a low-grade credit rating, rarely experience default. Table 5 illustrates the credit transition matrix of corporate debt rated by Moody's. Given 75 years of experience between 1920 and 1996, which included many recessions and one depression, the table shows how the credit rating of a corporate bond has changed annually. It is important to note that the transition probabilities vary according to the business cycle and need not apply to companies not covered by the sample. A bond rated "Aaa" has a 92.3 percent probability of retaining a "Aaa" classification after one year, a 6.4 percent chance of being downgraded to "Aa," and so forth. Based on the long period studied, the annual probability of default by a high-grade bond is almost negligible (e.g., 0.00% and 0.06%), the chance of default by a medium-grade firm is small (e.g., .13% and .30%), and even low for low-grade debt the chance of default increases significantly (e.g., 1.23% for "Ba", 3.20% for "B" and 13.5% for Caa/C).

Table 5
Moody's Corporate Transition Matrix (1920 to 1996)

Initial Rating	Probability of Rating after One Year							
	Aaa	Aa	A	Baa	Ba	B	Caa/C	Default
Aaa	92.28%	6.43%	1.03%	0.24%	0.02%	0.00%	0.00%	0.00%
Aa	1.28%	91.68%	6.09%	0.70%	0.17%	0.02%	0.00%	0.06%
A	0.07%	2.45%	91.59%	4.97%	0.67%	0.11%	0.02%	0.13%
Baa	0.03%	0.26%	4.19%	89.41%	5.07%	0.66%	0.07%	0.30%
Ba	0.01%	0.09%	0.43%	5.09%	87.23%	5.47%	0.45%	1.23%
B	0.00%	0.04%	0.15%	0.67%	6.47%	85.32%	3.44%	3.90%
Caa/C	0.00%	0.02%	0.04%	0.37%	1.38%	5.80%	78.78%	13.60%

The market perceives that lower rated debt is more risky, and investors require a higher return for those securities whose rating is downgraded. Bond prices decline and investors suffer losses when debt is downgraded; a downgrade is far more likely than default for most corporate debt. Empirical studies show that rating agencies lag the market's recognition of altered credit risk. (Ederington, L., Yawitz, J. and Roberts, B., 1987)

Latin American firms comprise almost five percent of international debt issued by corporations as of 2000. By contrast, Latin American issues account for over ten percent of governmental debt. Mexican companies represent almost two percent of the corporate debt outstanding while firms from both Argentina and Brazil each account for about one percent each. The proportion of Latin American corporate debt should increase and the importance of governmental debt decline as more public enterprises are privatized.

No Latin American corporate debt currently qualifies for a credit rating of "A" or better rating given the ratings assigned Mexico and countries in both South and Central America. The recent economic turmoil and default by Argentina will likely extend the period until countries are rated "A" or better. Countries currently assigned lower medium-grade will become upper medium-grade with the passage of time and stable economic growth. Corporate bonds rated "A" are weighted 50 percent for risk-based capital requirements, while corporate debt rated "Baa" and "Ba" is weighted 100 percent and debt rated "B" or lower rated is 150 percent. The majority of Latin American corporate and bank debt currently would be weighted 150 percent and 100 percent respectively. Is the indicated capital imposed by the new capital accord justified? This important question is addressed empirically by application of an advanced simulation model.

Risk management simulation

Risk assessment methodologies seek to assess the maximum potential change in the value of an asset or an asset portfolio with a stated probability over a pre-set horizon resulting from changes in interest rates, basis risk and credit risk. The risk in owning a portfolio of risky fixed-income securities is a function of changes in the risk-free term structure of interest rates, macro-economic conditions that affect the overall risk premium of an asset class, and the credit quality of the assets within a portfolio. The current practice to assess risk exposure typically evaluates market and credit risks independently. The practice misstates risk exposure at both the security and the portfolio level. Credit risk and market risk are correlated; therefore an integrated risk assessment methodology is critical. (Fridson, M., Garman, C. and Wu, S., 1997)

We here apply a diffusion-based methodology for assessing the value-at-risk (VaR) of a portfolio of fixed-income securities comparable to those now issued and likely to be issued for the foreseeable future by firms in Latin America. This is accomplished by simultaneously simulating both the future environment in which financial instruments will be valued and the credit rating of specific firms. Readers interested in the valuation model are invited to read the authoritative reference related to the model (Barnhill, T. M. and Maxwell, W. F., 2002), or refer to Appendix - 1 for a technical summary. Appropriately calibrated for the volatility of the period and firms to be studied, the simulation methodology produces reasonable credit transition probabilities, valuations for bonds with credit risk, and portfolio value-at-risk measures to include the marginal impact of each risk factor.[1] For the current application, the model was calibrated on US financial data for the period 1993-1998. Market volatility estimates were based on 1998 data, which included the Asian financial crisis. It is important to note that market volatility is higher for many Latin American countries than for the US. Thus, it would be expected that under Latin American conditions bond portfolio risk levels would be somewhat higher than those discussed below. However, the higher market volatility is partly captured by the lower international credit ratings assigned both countries and companies from Latin America. The model can be extended to evaluate asset/liability management risk as well as systemic risk within a financial system. (Barnhill, T. M., Papanagiotou, P. and Schumacher, L., 2000)

1 The proposed integrated risk assessment methodology allows for a direct estimation of portfolio risk level which is not available when market and credit risk are estimated separately and added together in an ad hoc manner (e.g. the proposed *New Basel Capital Accord*).

Market Risk - The price of a fixed-income security is a function of the term structure of interest rates. The term structure refers to the relationship of required yield and maturity. The value of an asset reflects the present value of projected cash flow discounted at a rate commensurate with term and risk. The distribution of potential cash flow varies with the credit quality of the bond and the market's required credit and liquidity risk premia. For current simulation purposes, we evaluate eight asset classes into which a bond may rest that range from "Aaa" to default. The term structure of interest rates, excluding the default category, is modeled as a stochastic variable. The Hull and White extended Vasicek model is used to model stochastic risk-free interest rates that are assumed to follow a mean-reversion process with a time-dependent reversion level. (Cox, J. C. *et al.*, 1985; Hull, J., 2000; Van Horne, J. C., 2001)

To simplify the exposition, we focus the VaR analytical illustration at the 95 percent confidence level. That is, the analysis shows the minimum amount an investor should anticipate losing five percent of the time. The time period analyzed is one year. Table 6 illustrates the interest rate or market risk of three classes of ten-year, US dollar-denominated bonds. The credit quality ranges from "A" to "B" with a focus on corporate asset classes rated as 50%, 100% and 150% for risk-based capital purposes. Note that upper medium-grade "A-rated" bonds may incur a loss equal to at least 6.0 percent of their mean present value five percent of the time periods analyzed. Meanwhile, low-grade "B-rated" bonds will lose at least 4.7 percent or more of their mean value five percent of the time.

Table 6
Value-at-risk Analysis for Individual Bonds
(Percentage Loss in Mean Value @ 95% Confidence Level)

	Bond Rating		
Risk	A	Baa	B
Market Risk	-6.0%	-5.5%	-4.7%
+ Basis Risk	-6.1%	-5.7%	-10.9%
+ Credit Risk	-6.8%	-19.5%	-45.6%

Low-grade bonds expose investors to less market risk than high-grade bonds with the same maturity. Low-grade bonds carry a high coupon to reward investors for the increased uncertainty of repayment. The high coupon leads to a lower effective duration. Duration measures the elasticity of a change in bond price to a change in interest rates. Duration declines as more cash flow is projected more quickly. Short-term bonds have a lower duration than long-term

bonds. High coupon bonds have a lower duration than zero coupon bonds. To illustrate, the effective duration of a 10-year "A-rated" note with a 7 percent coupon priced at par is 7.1 while the effective duration of a 10-year "B-rated" note with a 10 percent coupon priced at par is 6.2. Assuming interest rates follow a stochastic mean-reversion process, low-duration bonds expose investors to less market risk than high-duration bonds. However, interest rate movements between medium- and low-grade bonds do not necessarily change in a parallel manner over the business cycle.

Basis Risk - Basis risk represents the relationship of interest rates for securities of comparable term or maturity. Basis risk exists because investors require yield premiums that change over time. Credit risk and liquidity risk premiums increase during periods of financial uncertainty induced by country risk crises and/or economic recessions. Investors seek "safety." Credit risk and liquidity risk premiums narrow during economic prosperity. Investors "reach for yield."

We estimate the term structure applicable to a "Aaa" security as a stochastic log- normal spread over the risk-free term structure, and then sequentially estimate the term structure of the next lower credit quality by applying a log-normal spread over the term structure of the next higher corporate quality yields. The mean value of the simulated credit and liquidity basis spreads are set to approximately equal the forward yields implied by the initial term structures for various credit quality grades. Basis spreads are more volatile for lower grade debt given the willingness of investors to accept lower spreads during "good times" but need to be compensated with higher spreads during "bad times."

The effect of introducing basis spreads to that of market risk already discussed is also shown in Table 6. Note that the potential loss with 95 percent confidence for securities of any credit quality is now higher than when the analysis is limited to market risk alone. Bonds rated "Baa" exhibit the lowest VaR at a five percent confidence level when basis risk is added to market risk. Lower medium-grade "Baa" bonds lose at least 5.7 percent of their mean value compared to a 6.1 percent loss for upper medium-grade "A" bonds and a much higher potential loss of 10.9 percent for low-grade "B" debt. The incremental basis spread required for debt rated "Baa" is not sufficient to offset their lower effective duration and market risk. It is instructive to note how much incremental risk occurs as a result of introducing basis risk to the modeling exercise. The VaR for "A-rated" bonds increases .1 percent, compared to a change of .2 percent for "Baa-rated" debt and a very wide 6.2 percent marginal loss for "B-rated" notes. Any analytical model that assumes a parallel change of interest rates across instruments of varying credit quality will not capture basis risk. Clearly, basis risk increases as credit quality declines. Basis risk premiums change over the business cycle. While market risk and basis

risk are important, credit risk is even more important when modeling risk exposure with medium- and low-grade debt.

Credit Risk - Bond ratings change over time. In some cases, bonds default. The loss incurred from default is a function of the recovery value, if any, that results from a firm not meeting interest or principal payments on a timely basis and/or not fulfilling covenants related to an indenture. High-grade corporate bonds possess a very low probability of default within one year. The potential for default and loss increases as the credit rating declines. Basis risk evaluates how the value of a given quality bond may change given shifts in required yield for the given quality of bond. Credit risk evaluates how the value of a bond may change given a shift in credit rating that includes upgrades, downgrades and default.

The simulation evaluates credit risk by way of a reduced form contingent claims analysis. The shareholders of a firm hold a call option on the firm and the debt ratio (liabilities/assets) provides a measure of how far the call option is in the money. (Jorion, P., 2000) According to a contingent claims analysis, the value of a firm can be described by a diffusion-type stochastic process. Other assumptions include:

- The value of the debt measured by the debt ratio refers to the face value or cash flow applicable to liabilities due at maturity;

  The default-free interest rate and basis spreads are correlated, stochastic variables;

- The firm's debt ratio and volatility can be used to determine the approximate risky term structure to value a bond's cash flow;

- If the bond defaults, the recovery rate is stochastic and drawn from a distribution with a known mean (34%) and standard deviation (25%); (Altman, E., 1993)

- The dividend yield is constant over the time period simulated; and

- The firm retains an expected growth rate of assets and a target debt ratio that is constant.

Given the low probability of default, high- and upper medium-grade bonds are less affected by introducing credit risk to the analysis than lower medium-grade and low-grade bonds. The risk premium increases dramatically when bonds are classified low-grade because of the segmented investor market for high-yield bonds, and the higher probability of default and related loss.

The VaR analysis when credit risk is introduced is also shown in Table 6. According to the 10,000 simulations run for each result, a single "A-rated" bond may lose 6.8 percent or more of its mean value approximately five percent of the one-year time periods studied. As shown by Table 5, "A-rated" bonds exhibit a 2.52 percent chance of being upgraded in one year, but a 5.77 percent probability of being downgraded and a .13 percent probability of default within one year. There is more downside risk than upside potential. As a result, the VaR increases by 7 percent for "A-rated" bonds when credit risk is simulated together with market and basis risk. By contrast, the VaR jumps by 13.8 percent for "Baa-rated" debt and explodes by 34.7 percent for "B-rated" notes. Debt rated "Baa" historically has retained a 4.48 percent probability of being upgraded compared to a 5.80 percent chance of downgrade and a .30 percent chance of default. Although notes rated "B" have a 7.33 percent probability of being upgraded in one year versus a 3.44 percent of being downgraded, the market premium for a "Caa" rating is very high. Further, debt rated "B" has a 3.90 percent chance of defaulting in one year; this is not a trivial probability given the loss incurred given default.

It is important to note that banks subject to *The New Capital Accord* would likely be required to keep capital equal to 5 percent of "A-rated" debt (50% risk weight), 10 percent of "Baa-rated" bonds (100% risk weight) and 150 percent of "B-rated" notes (150% risk weight) to be considered well-capitalized for the risk-based capital rule. However, the VaR analysis shown in Table 6 indicates the value-at-risk of a single bond with a five percent confidence level substantially exceeds such prudential capital requirements. The indicated capital backing appears too low for all three classes of bonds; the shortfall is especially low as the credit rating class approaches ratings common to Latin American firms whose debt has been or is likely to be rated by the international credit rating agencies. The VaR analysis considers the effect of a change in interest rates, basis spreads and credit risk for an individual bond; investors, however, invariably hold a portfolio of bonds. By evaluating risk in isolation, the potential advantage of diversification is ignored.

Portfolio value-at-risk

To perform portfolio analysis, we form portfolios of financial instruments that range from one bond already discussed to 20 and then 100 bonds. Each bond is assumed to have a ten-year term, US dollar-denomination and similar credit quality. Table 7 illustrates the VaR for a portfolio of bonds drawn from the same industry. The VaR declines a little for debt rated "A" as more instruments are included in a portfolio. The VaR at the five percent level of confidence declines by .2 percent from a loss of 6.8 percent with one bond to a loss of 6.6 percent with 100 bonds. Adding more bonds to a upper medium-grade bond portfolio has little affect on

risk exposure. By contrast, the VaR declines by 11.0 percent from a loss of 19.5 percent with one instrument to a loss of 8.5 percent for a lower medium-grade debt portfolio of 100 securities. The VaR plummets by 29.4 percent for low-grade debt when a portfolio is increased from one to 100 issues. Diversification is clearly more important for lower quality debt common to Latin American issuers. It is less likely that a large number of securities would be downgraded and/or default at the same time; portfolio analysis derived from the diffusion-based simulation is able to capture and measure the advantage of diversification.

Table 7
Total Value-at-risk Analysis for Portfolio of Bonds from a Single Sector
(Percentage Loss in Mean Value @ 95% Confidence Level)

	Bond Rating		
Number of Bonds	A	Baa	B
1	-6.8%	-19.5%	-45.6%
20	-6.6%	-8.8%	17.3%
100	-6.6%	-8.5%	16.2%

Correlation among firms declines when firms of different industries are introduced to a portfolio. Table 8 illustrates how portfolio VaR changes when the portfolio of bonds simulated include up to twenty different industries. Again, the VaR declines a little for debt rated "A." The VaR falls from 6.8 percent to 6.5 percent with 20 bonds drawn from twenty industries and to 6.3 percent with 100 bonds from twenty industries. The risk reduction is far more dramatic for bonds rated "Baa" and "B." The VaR declines from 19.5 percent for "Baa" debt analyzed individually to 7.2 percent for a portfolio of 100 bonds from twenty industries. Similarly, the VaR falls from 45.6 percent for debt rated "B" when analyzed individually to 13.6 percent from a large, diversified portfolio. Barnhill and Maxwell have shown that such simulated portfolio VaR analyses are very similar to the historical VaR levels for actual bond portfolios. (Barnhill, T. M. and Maxwell, W F., 2002)

The *New Basel Capital Accord* requires banks using the standardized capital rule to maintain 100 percent more capital (e.g., 10% v. 5%) for a "Baa-rated" bond than an "A-rated" note, and 200 percent more capital (e.g., 15% v. 5%) for a "B-rated" bond than an "A" note. The VaR analysis derived from Table 8 indicates that there is more risk with lower grade debt. However, the analysis simulates the simultaneous implications for VaR given changes in interest rates, basis spreads and credit risk for a diversified portfolio. The VaR analysis suggests there

is only 14 percent more risk (i.e., 7.2% VaR v. 6.3% VaR) for "Baa" debt and 115 percent more risk (i.e., 13.6% VaR v. 6.3% VaR) for "B" notes. The incremental capital required by the revised capital accord more than covers the incremental risk of well-diversified investors in both lower medium-grade and low-grade debt. Assuming that the 95 percent VaR confidence level is the appropriate risk measure, the proposed capital charge does not appear excessive when the correlated risks are measured in a diversified portfolio context.

Table 8
Total Value-at-risk Analysis for a Portfolio of Bonds and Sectors
(Percentage Loss in Mean Value @ 95% Confidence Level)

		Bond Rating		
Sectors	Bonds	A	Baa	B
1	1	-6.8%	-19.5%	-45.6%
20	20	-6.5%	-7.7%	-15.3%
20	100	-6.3%	-7.2%	-13.6%

Summary

Current risk estimation methodologies calculate market risk and credit risk in separate analyses and often ignore basis risk. There is no reliable method for combining these risk measures into one overall portfolio risk assessment. Such risk estimation errors have significant implications for many types of financial decisions to include bank capital adequacy requirements. Using market volatility estimated from US data for 1998 which included substantial global market turmoil, this paper applies a simulation model to assess correlated market, basis and credit risk for both individual bonds and a portfolio of bonds comparable to those issued by Latin American companies in the international financial market. Interest rate or market risk is relatively more important for high-grade bonds issued by strong companies from developed countries. Basis risk and credit risk are more important for companies from countries whose sovereign debt is rated lower medium-grade and low-grade.

The value-at-risk with a 95 percent confidence level for a lower medium-grade bond or low-grade bond is very high when analyzed individually. The risk of owning a well-diversified portfolio of lower credit quality corporate bonds is shown to be reduced to manageable levels. The value-at-risk from a diversified portfolio of bonds comparable to those issued by Latin

American firms is simulated using US volatility levels to lie within revised capital standards. It is important to note that value-at-risk estimates show much greater losses for lower grade bonds individually or in a portfolio context when evaluated at a 99 percent confidence level than the 95 percent level illustrated in this analysis.

It is also important to note that the simulated portfolio risk levels would increase if emerging market volatility levels were utilized. Yet, the lower international credit ratings of both countries and companies in Latin America partly reflects such risk. Private capital formation in Latin America should not be impeded by the revised capital requirement. Equity capital requirements appear consistent with risk exposure; the global rule should not distort the ability of bank investors to create value for shareholders based on a traditional risk/reward financial market dichotomy.

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Appendix 1 - Simulation methodology

A. Model description

In this study, we employ a methodology similar to that used by Barnhill and Maxwell (2002). We first simulate the future financial environment and then estimate the credit quality of the firm and the value of the security in question within that financial environment.

The financial environment is modeled as a set of correlated term structures (U.S. government, AAA, ..., CCC) and a correlated equity market index. We simulate the stochastic risk-free rates using the Hull and White (1990, 1993, and 1994) extended Vasicek model. The interest rate is assumed to follow a mean-reversion process with a time dependent reversion level.

$$\Delta r = a[(\theta(t)/a) - r]\Delta t + \sigma\Delta z \qquad (1)$$

$$\theta(t) = F_t(0, t) + \alpha F(0, t) + \frac{\sigma^2}{2a}(1 - e^{-2at}) \qquad (2)$$

Here, Δr is the risk-neutral process by which r changes, r is the instantaneous continuously compounded short-term interest rate, a is the mean reversion rate, $\theta(t)$ is used to calibrate the model, $F(0, t)$ is the forward rate at t calculated at 0, Δt is a small increment of time, σ is the

instantaneous standard deviation of r, and Δz is a Wiener process driving term structure movements with $\Delta z = \varepsilon\sqrt{\Delta t}$ The AAA term structure is modeled as a correlated log-normal spread over the risk-free rate, AA is modeled as a correlated log-normal spread over AAA, and so on.

The simulated values of equity market indices (S) assumes that S follows a geometric Brownian motion with constant parameters.[2] The expected growth rate (μ) is equal to the expected return on assets (μ) minus its dividend yield (θ).

$$S + \Delta S = S \exp[(m - \frac{\sigma^2}{2})\Delta t + \sigma\varepsilon \sqrt{\Delta t}\,] \qquad (3)$$

The correlations between interest rates and market equity returns are modeled using the n-variate normal distribution procedure described by Hull (2000, p. 409).

Modeling credit quality starts by modeling the value of the firm. In particular, the value of the firm is assumed to follow the following stochastic process:

$$dV = (\alpha V - C)dt + \sigma dz \qquad (4)$$

Here, V is taken to be the sum of the market value of the firm's equity plus the face value of its debt. The parameter α is the instantaneous expected rate of return on the firm per unit of time, C is the total dollar amount paid by the firm to either stockholders or bondholders, σ^2 is the instantaneous variance of return per unit of time and dz is a standard Gauss-Wiener process. It is assumed that the firm's debt ratio (D/V) and volatility (σ) can be used to determine the appropriate risky term structure to value the cash flows of the bond.

The return on a firm's equity is estimated using the capital asset pricing model. For this purpose, the return on the market index (K_m) is estimated as $K_m = (DS/S) + \theta$ and the return on equity for individual firms is simulated using equation (5), where ε is a random sample from a standardized normal distribution.

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2 While the lognormal assumption for stock prices has known limitations (e.g. the problem of "fat tails") it is still very widely used because it adequately represent many empirical distributions (see Jorion, 2000, p. 113). Also it should be noted that assuming a lognormal distribution for equity index prices does not imply that we are using a lognormal distribution for bond prices. In fact the distribution of bond prices will be driven by the correlated changes in interest rates, and bond credit ratings, as well as the maturity of the bond at the end of the simulation time step.

$$K_i = R_F + \beta_i(K_m - K_{RF}) + \sigma_i \Delta z \qquad (5)$$

The resulting equity returns are in turn used to simulate a distribution of future equity market values and debt ratios. The debt ratios are then mapped into credit ratings. Finally, the value of the bond at an assumed time step is calculated using the simulated term structure appropriate for that risk class. If the bond defaults, the recovery rate is modeled as a beta distribution with an assumed mean value and standard deviation.