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Risk Weights in Regulatory Capital Standards: Is It Necessary to “Get It Right”?

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Abstract: In recent decades, bank regulators have become increasingly reliant upon quantitative regulatory capital standards as a means of ensuring that banks hold adequate capital. The risk-based capital standards, from the 1988 Accord through the current Basel II standards, have primarily relied upon a building block approach to capital through the use of risk weights assigned to assets and off-balance sheet activities. Despite enhancements to improve the accuracy of risk-based capital standards, they continue to result in unintended consequences as the use of risk weights brings with it errors in the measurement of risk. Given the ongoing efforts by bank regulators to quantitatively assess risk, and correspondingly required capital, this study asks whether it is necessary for regulators to accurately assess risk weights in the risk-based capital standards. The simulation results suggest that, in order to minimize the unintended consequences associated with regulatory capital requirements, it is necessary for regulatory requirements to accurately mimic banks’ internal capital allocation processes.

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1. Introduction

In recent decades, bank regulators have increasingly relied upon quantitative approaches to determine appropriate levels of capital for banks, and in doing so, limit banks’ use of leverage. The rationale for bank regulation lies, among others, with bank regulators’ need to prevent excessive risk taking ex ante (Rochet, 1992; Dewatripont and Tirole, 1994), to protect against the costs of financial distress, including systemic risk (Goodhart, Hoffman and Segoviano, 2004) and to protect the deposit insurance fund (Berger, Herring and Szego, 1995). To that end, regulators have at their discretion a wide variety of tools for regulating banks including minimum capital requirements, supervisory oversight and enforcement powers, and reporting requirements and disclosure. While regulators have proposed enhanced supervision and increased disclosure in recent years (Basel Committee, 2006), minimum regulatory capital requirements continue to be the focal point of much of the bank regulatory process. This, despite the fact as noted by VanHoose (2007) that the existing research on capital requirements yields mixed results about the effectiveness of regulatory capital requirements.

Regulatory capital standards have undergone considerable change in recent decades. Prior to the 1980s, bank regulators evaluated capital adequacy by comparing a bank’s capital ratio with the capital ratios of a group of peer institutions (Gilbert, Stone and Trebing 1985). Beginning in the early 1980s, U.S. bank regulators applied a leverage requirement for banks that mandated a fixed minimum amount of capital relative to a

bank's total assets.¹ However, as noted by Alfriend (1988), a weakness of the leverage ratio is that it explicitly fails to incorporate risk, thereby creating an incentive for banks to shift their balance sheets from low-risk to high-risk assets, including an increase in off-balance sheet activities.

Given the inherent limitations of the leverage ratio, in 1988, U.S. bank regulators, as part of the international Basel Committee on Banking Regulation and Supervision, adopted risk-based capital standards.² Referred to as Basel I, the risk-based standards had multiple purposes, including making regulatory capital requirements consistent with the perceived credit risk in banks' assets and off-balance sheet activities. While not the first attempt at explicitly incorporating risk into minimum regulatory capital requirements,³ the 1988 Accord began the current effort to quantitatively incorporate risk into minimum capital requirements. To accomplish this goal, the 1988 standards assigned assets and off-balance sheet activities to one of four risk weight categories, with assets having more credit risk being assigned to higher risk weight categories than lower risk assets. Institutions were then required to hold capital equal to a minimum of 8 percent of the total of its risk-weighted assets. Originally intended to be a simple way to incorporate risk into capital requirements (Office of the Comptroller of the Currency, 1989), as regulators did not want regulatory capital standards to influence banks balance sheet decisions (Greenspan, 1998), the simplicity of the 1988 standards ultimately resulted in regulatory capital arbitrage (Jones, 2000) as banks took steps to mitigate the effects of the 1988 Accord. Moreover, these "cosmetic" adjustments to bank portfolios

¹ For a more complete discussion of bank regulation prior to the 1980s, see Gilbert et al (1985).

² It should be noted that, despite the weaknesses of the leverage ratio requirements, and the adoption of risk-based capital standards, regulators continue to apply leverage requirements to banks.

³ See Alfriend (1988) for a discussion of the history of this issue.

ultimately made the total risk-based capital ratio less reliable as a measure of the financial condition of banks (Office of the Comptroller of the Currency, 1998).

In the late 1990s, recognizing the coarseness of the risk-based standards in differentiating levels of credit risk, regulators, in both the U.S. and abroad, began work on a revised Accord. Among the changes in the revised Accord (Basel II) are increased granularity in recognizing differences in credit risk in minimum capital requirements (Pillar 1), enhanced supervision (Pillar 2), and enhanced disclosure requirements (Pillar 3). Under Pillar 1, the standardized version of the revised Accord continues to rely on risk weights, albeit with risk weights that differ by the credit rating of the underlying borrower, while the internal ratings-based approaches allow banks to use some elements of their internal risk models in calculating their minimum capital requirements.⁴

While regulatory capital standards have and continue to evolve, they remain blunt instruments that are, at least to some degree, applied uniformly across banks. Furthermore, despite attempts to improve the accuracy of regulatory capital standards, one difficulty regulators continue to encounter is that changing regulatory capital requirements inevitably result in unintended consequences. To bank regulators, the unintended consequences of regulatory capital standards are not surprising given the historical experience with risk-based regulation and the rapid pace of financial innovation (Kashyap, Rajan, and Stein, 2008), and banks desire to respond to regulatory capital requirements in the least costly manner (Jackson et al, 1999). These unintended consequences are generally one of two types. First, they may be asset specific in nature,

⁴ Under the revised Accord there are two internal ratings based approaches: the foundation internal ratings based (IRB) approach and the advanced internal ratings based (IRB) approach. For details, see Basel Committee (2006). The internal ratings based approaches allow, to varying degrees, banks to use their own estimates of the probability of default (PD) and loss given default (LGD) in the calculation of capital requirements.

with a resulting change by banks in the composition of their balance sheets. For example, these unintended consequences may manifest themselves as regulatory capital arbitrage, as regulatory capital requirements contain imperfections that banks exploit to undertake profitable activities while minimizing the capital they must hold against such activities. Regulatory capital arbitrage may be thought of in one of two broad senses. First, regulatory capital arbitrage may result in new assets or activities that contain significant risk positions, yet are designed to minimize the effects of the new regulatory capital requirements (Jones, 2000). Regulatory capital arbitrage may also manifest itself in the form of asset reallocation as banks seek to exploit situations where the regulatory capital requirement applied to an asset is less than the internal economic capital allocation a bank would undertake against the asset (Mingo, 2000). This may be thought of as the cherry-picking form of regulatory capital arbitrage.

Secondly, the unintended consequences of regulatory capital standards may be macroeconomic in nature. In the view of traditional macroeconomics, bank capital is innocuous and irrelevant to macroeconomic activity, in general and monetary policy, in particular (Friedman, 1991). For example, in the Modigliani and Miller (1958) world with perfect capital markets, bank lending is independent of whether banks use deposits or capital to fund their asset portfolios. More recently, the idea that the level of capital a bank holds can influence both monetary policy and the level of macroeconomic activity has garnered increased attention (Stein, 2002). Here examples include studies of the impact of the 1988 Basel Accord on bank credit, a period often referred to as the credit crunch (Hancock and Wilcox, 1994; Peek and Rosengren, 1995; Jackson et al, 1999; Furfine, 2001), the potential for the Basel II standards to amplify business cycles –

procyclicality (Borio, Furfine and Lowe, 2001; Lowe, 2004; Heid, 2007), and, the impact of regulatory capital standards on the effectiveness of monetary policy (Van Den Heuvel, 2002a, 2002b).

Regardless of the nature of the unintended consequences, banks can be expected to alter their balance sheets and their risk levels in response to changing regulatory capital standards (Koehn and Santomero, 1980, Kim and Santomero, 1988). One option is for banks to raise capital. Myers and Majluf (1984) argue that firms have a pecking order for increasing capital with internally generated funds being preferred. Furthermore, raising capital externally can be prohibitively expensive (Berger et al, 1995; Estrella, 2004), particularly for banks that are capital constrained or during periods of uncertainty. Nevertheless, history suggests that some banks did in fact increase their regulatory capital ratios in response to introduction of the risk-based capital standards in 1988 (Jacques and Nigro, 1997). Alternatively, some banks may opt to shrink the size of their asset portfolios. As has been discussed extensively with regard to the 1988 risk-based capital standards, if the risk weights assigned to an asset is nonzero, banks can improve their regulatory capital ratios by reducing assets, in general, and assets carrying higher risk weights, in particular (Haubrich and Wachtel, 1993). Finally, differential risk weights on assets highlight a third possible response to changing regulatory capital ratios and that is for banks to alter the relative composition of their assets. For example, viewed as a regulatory tax that places higher tax rates on commercial loans than government securities (Berger and Udell, 1994), banks can increase their regulatory capital ratios by simply shifting their portfolios from high risk-weighted assets to lower risk-weighted assets.

Despite the unintended consequences arising from minimum regulatory capital requirements, regulators continue to debate how best to explicitly incorporate risk into regulatory capital requirements, as well as the appropriate role for supervisory review and market discipline (Decamps, Rochet and Roger, 2004). The goal behind revising regulatory capital standards is to more closely align regulatory capital requirements with banks' internal capital allocations (Caruana, 2005) while minimizing the unintended consequences, including regulatory capital arbitrage, associated with capital regulations. While regulatory capital standards have continued to evolve over time, regulators have historically relied upon uniform capital standards as the primary means of ensuring capital adequacy; they continue to do so today.

And with that continued reliance has come a continued reliance upon the building-block approach, with risk weights and risk weight categories used to determine capital requirements. For example, the standardized version of Basel II has partially resolved the risk-invariant problems present in determining the capital requirements on commercial lending present in the 1988 Accord by requiring commercial loans to be assigned to the risk weight category consistent with its underlying credit rating. But the use of risk weights in regulatory capital standards brings with it errors in measurement; Treacy and Carey (1998) note that many banks' internal risk rating systems contain 8 or more risk weight categories. Given that the use of risk weights results in errors in measurement, Herring (2005) concludes that despite attempts to revise the 1988 Accord, even more recent regulatory advances in capital requirements, such as the Basel II standards, will not eliminate regulatory capital arbitrage.

In an environment where regulators seek to improve the accuracy of regulatory capital standards while minimizing unintended consequences, the purpose of this paper is to examine a basic question regarding the use of risk weights in formulaic capital requirements. With the current emphasis on quantitatively assessing risk for the purpose of determining capital adequacy, and the continued reliance upon risk weights and uniform capital ratios, this paper asks whether it is necessary to accurately establish risk weights in regulatory capital standards.

2. The Model

Extending earlier work by Kopecky and VanHoose (2004, 2006) and Jacques, Thornton, and Coadari (2010), a one-period quadratic adjustment cost model of the banking sector is written such that:

$$H + L = D + K \tag{1}$$

$$C_H = (f/2)H^2 \tag{2}$$

$$C_L = (g/2)L^2 \tag{3}$$

$$C_D = (j/2)D^2 \tag{4}$$

$$C_K = (k/2)K^2 \tag{5}$$

$$K \geq d(\varepsilon_H w_{I-H} H + \varepsilon_L w_{I-L} L) \tag{6}$$

Equation (1) is the bank balance sheet condition. For simplicity, it is assumed that banks hold only two types of assets, with H representing high-risk assets and L representing low-risk assets, where the assets are differentiated by their inherent level of credit risk.

High-risk assets may be thought of as commercial loans with lower grade credit ratings, while low-risk assets may include higher credit quality corporate loans or government securities. The liability side of the balance sheet is made up of two sources of funding, with D representing non-transactions deposits and K representing capital. Equations (2) through (5) assume quadratic costs for the assets, liabilities, and capital, respectively, with increasing marginal costs in H, L, D, and K. The quadratic adjustment cost parameters f , g , j , and e imply that banks may incur significant costs in adjusting their balance sheet. The inclusion of adjustment costs in equations (2) through (5) has important implications for both banks and bank regulation. As has been discussed in the literature, regulatory capital arbitrage arises in situations where regulatory capital requirements deviate from economic capital requirements. If banks incur no costs for adjusting their balance sheets, then they may freely and completely exploit regulatory capital arbitrage opportunities. But if adjustment costs exist, then banks seeking to exploit deviations of the regulatory capital requirements from economic capital requirements must weigh the benefits of exploiting the discrepancy -- a reduction in required capital -- against the cost of adjusting the balance sheet item.

Equation (6) represents the regulatory capital standards. The variables w_{I-H} and w_{I-L} represent a bank's internal risk classification of the risk of assets H and L, respectively. Consistent with Jones and Mingo (1998), we assume that a bank's internal ratings classification provides the most accurate assessment of the credit risk of an asset. Furthermore, the terms $\varepsilon_H w_{I-H}$ and $\varepsilon_L w_{I-L}$ in equation (6) represent the risk-weight categories the high-risk and low-risk asset are assigned to under a regulatory risk-based capital standard. Here errors in the risk weights introduced by the regulators are assumed

to be multiplicative in nature, with the terms ε_H and ε_L representing the errors in the regulatory risk weight of the high-risk and low-risk asset, respectively. Errors in the risk weights potentially bring about regulatory capital arbitrage on the asset side of the balance sheet, and as noted earlier may cause the level of capital held by financial institutions to be incorrect, given the asset structure.

Despite the continuing evolution of regulatory capital requirements in recent decades, regulatory capital standards continue to contain errors. One possibility is that regulatory capital standards are overly simplistic as they may fail to account for risk (e.g., leverage ratio) or in being so simplistic, are too blunt (e.g., Basel I) to accurately assess risk. A second possibility is one of omission. In being simplistic, regulatory capital standards have not yet become sophisticated enough to adequately assess risk. An example here would be the failure of some of the risk-based capital standards to account for portfolio diversification in the risk weights, a problem often cited with regard to the 1988 Accord. Third, because the risk-based capital standards are the work of a host of regulatory agencies, both in the U.S. as well as a variety of foreign countries, the standards may reflect not only a quantitative assessment of the risk of an asset, but also political compromise on the part of regulators in crafting an international regulatory standard.

Furthermore, despite the greater reliance on internal models under the internal ratings based approaches to Basel II, even these standards contain risk weights that are likely to include errors. The Basel Committee (2004) notes that, with the use of banks' estimates of probabilities of default, loss given default, and exposure at default, the risk measures are converted into risk weights. Kaufman (2004) argues that these loss rates

are subject to significant errors, while Herring (2005) argues that the internal ratings based approaches will differ from internal models in four important respects, including that the model determining the risk weights is that of the regulators.

To further complicate matters, the errors in risk weights are unlikely to be remedied by regulators, even as regulatory capital standards continue to evolve. As written, risk-based capital standards are generally a uniform set of rules delineating which assets and off-balance sheet activities are assigned to which risk weight categories and setting a minimum risk-based capital ratio. These standards are then uniformly applied to all internationally active banks under the purview of the corresponding regulatory agency. But as written, the risk weights applied to assets are often codified in the regulatory capital standards, and given that the risk weights contain errors, the errors have also become codified in the capital standards. An example of this can be seen in 12 CFR Part 3 (final rule) as published in the Federal Register by the U.S. bank regulatory agencies, where claims on private obligors are placed in the 100 percent risk weight category regardless of credit risk (Office of the Comptroller of the Currency, 1989).

Returning to the specification of regulatory capital standards in equation (6), if ε_H or $\varepsilon_L > 1$, then the risk weight category an asset is assigned to is too high, as banks' internal risk classification systems suggest a more accurate assessment of risk is w_{I-H} or w_{I-L} , respectively. An example of this would be the assignment of AAA credits to the 100 percent risk weight category under the 1988 Accord, as research by Altman and Saunders (2001) and Resti and Sironi (2007) suggest that AAA credits belong in a significantly lower risk weight category. Alternatively, if ε_H or $\varepsilon_L < 1$, then the risk weight category an asset is assigned to is too low. A well-known example in this case

may be the assignment of loans rated B or lower to the 100 percent risk-weight bucket under the 1988 Accord. In this case, estimates by Altman and Saunders (2001) and Resti and Sironi (2007) suggest that these loans should be assigned to a higher risk weight category.

Finally, d in Equation (6) represents the minimum risk-based capital ratio as determined by bank regulators. Under both the Basel I and II standards, d is a fixed, minimum ratio equal to 8 percent. As a result, $d\varepsilon_H w_{I-H} H$ represents the amount of capital that must be held against H under the risk-based capital standards, while $d\varepsilon_L w_{I-L} L$ represents the amount of capital that must be held against L . Under the assumption that banks' internal risk systems adequately measure risk and allocate capital without error, $d w_{I-H} H$ is the amount of economic capital required under a bank's internal ratings system for H and $d w_{I-L} L$ is the amount of economic capital required for L .

Given equations (1) through (6), banks are assumed to maximize their profits (π) such that:

$$\pi = r_H H + r_L L - r_D D - \frac{f}{2} H^2 - \frac{g}{2} L^2 - \frac{j}{2} D^2 - \frac{k}{2} K^2 - \lambda_1 (D + K - H - L) - \lambda_2 (K - d(\varepsilon_H w_{I-H} H + \varepsilon_L w_{I-L} L)) \quad (7)$$

where r_H is the interest rate on high-risk assets, r_L is the interest rate on low-risk assets, and r_D is the interest rate on non-transactions deposits. In addition, λ_1 is the Lagrangian multiplier associated with the balance sheet condition while λ_2 is the multiplier associated with the regulatory capital requirement. In this model, assets are assumed to earn returns positively related to their credit risk and banks are assumed to compete in perfectly

competitive markets where interest rates are given. As a result, $r_H > r_L > r_D$. Finally, it is assumed that the time period is long enough that banks can adjust both their balance sheets and their capital levels.

3. Asset Allocation and Capital

To understand the impact of the structure of regulatory capital standards and their impact on bank balance sheets, we begin by examining the case where banks are not constrained by the risk-based standards. While the model detailed above is decidedly simple, the results in this section are often complex polynomials that add to the complexity of the analysis without significantly changing the results. Because the emphasis in this study is on the structure of regulatory capital requirements and their relationship to the allocation of assets and capital, and to mathematically simplify the analysis, the assumption is made that it is costless to adjust deposits, $j = 0$.

3.1 Nonbinding capital requirements

When regulatory capital standards are not binding, the Lagrange multiplier λ_2 equals zero and the profit-maximizing balance sheet allocation becomes:

$$H_U^* = \frac{r_H - r_D}{f} \quad (8)$$

$$L_U^* = \frac{r_L - r_D}{g} \quad (9)$$

$$D_U^* = \frac{gk(r_H - r_D) + fk(r_L - r_D) - fgr_D}{fgk} \quad (10)$$

$$K_U^* = \frac{r_D}{k} \quad (11)$$

with the subscript U signifying the unconstrained results. Equations (8) and (9) show that the optimal asset allocation of the bank is positively related to the spread between the interest rate on the asset and the interest rate on non-transactions deposits and negatively related to the marginal cost of adjusting the high-risk and low-risk asset positions, respectively. As interest rate spreads increase, banks desire to hold more of the respective assets, with a corresponding need for additional funding. Therefore, the optimal deposit holdings in equation (10) are positively related to the interest rate spreads on high-risk and low-risk assets and negatively related to the interest rate on the deposits themselves. Finally, given the additional assets being held, equation (11) reveals that banks hold more capital even though the regulatory capital standards are not binding.

3.2 Binding capital requirements

Banks may be formally constrained by the risk-based capital standards if $K < d(\varepsilon_H W_{I-H} H + \varepsilon_L W_{I-L} L)$. In this case, the risk-based capital standards are formally binding as the bank holds less than the 8 percent minimum ratio in capital and the Lagrange multiplier λ_2 is not equal to zero. In addition, some banks, although they meet the formal 8 percent risk-based standard, will act as if they are constrained by the standards. This may occur for any number of reasons, including a desire to expand business lines or engage in a merger (Haubrich and Wachtel, 1993), as protection against potential shocks to equity (Furlong, 1992), or as a signal to regulators or the market that a bank is in compliance with the regulatory capital standards (Jacques and Nigro, 1997). Finally, given possible forthcoming changes in the definition of regulatory capital under Basel III, some banks may become capital constrained even though they meet the 8 percent

minimum requirement under the current definition of regulatory capital.⁵ Regardless of the reason, under these conditions, banks that are not explicitly constrained under the current standards may behave as if regulatory capital standards are binding.

When regulatory capital standards are binding, or banks behave as if they are, the profit-maximizing balance sheet allocation becomes:

$$H_E^* = \frac{g(r_H - (1 - d\varepsilon_H w_{I-H})r_D) + d^2 \varepsilon_L w_{I-L} k(\varepsilon_L w_{I-L}(r_H - r_D) - \varepsilon_H w_{I-H}(r_L - r_D))}{fg + d^2(gk\varepsilon_H^2 w_{I-H}^2 + fk\varepsilon_L^2 w_{I-L}^2)} \quad (12)$$

$$L_E^* = \frac{f(r_L - (1 - d\varepsilon_L w_{I-L})r_D) + d^2 \varepsilon_H w_{I-H} k(\varepsilon_H w_{I-H}(r_L - r_D) - \varepsilon_L w_{I-L}(r_H - r_D))}{fg + d^2(gk\varepsilon_H^2 w_{I-H}^2 + fk\varepsilon_L^2 w_{I-L}^2)} \quad (13)$$

$$D_E^* = \frac{g(1 - d\varepsilon_H w_{I-H})(r_H - (1 - d\varepsilon_H w_{I-H})r_D) + f(1 - d\varepsilon_L w_{I-L})(r_L - (1 - d\varepsilon_L w_{I-L})r_D)}{fg + d^2(gk\varepsilon_H^2 w_{I-H}^2 + fk\varepsilon_L^2 w_{I-L}^2)} - \frac{d^2 k(\varepsilon_H w_{I-H} - \varepsilon_L w_{I-L})(\varepsilon_L w_{I-L}(r_H - r_D) - \varepsilon_H w_{I-H}(r_L - r_D))}{fg + d^2(gk\varepsilon_H^2 w_{I-H}^2 + fk\varepsilon_L^2 w_{I-L}^2)} \quad (14)$$

$$K_E^* = \frac{d(g\varepsilon_H w_{I-H}(r_H - r_D) + f\varepsilon_L w_{I-L}(r_L - (1 - d\varepsilon_L w_{I-L})r_D) + dg\varepsilon_H^2 w_{I-H}^2 r_D)}{fg + d^2(gk\varepsilon_H^2 w_{I-H}^2 + fk\varepsilon_L^2 w_{I-L}^2)} \quad (15)$$

Equations (12) through (15) continue to emphasize the importance of interest rate spreads and adjustment costs in determining not only banks' asset allocation, but also the dollars of capital. In contrast to the optimal levels in the non-binding case, when regulatory capital requirements are binding, or banks behave as if they are, the regulatory capital standards explicitly link the capital banks hold to the levels of H and L and the relative

⁵ Even banks that are not constrained by current capital regulations may become capital constrained under the forthcoming Basel 3 standards. This could occur because Basel 3 is likely to place a greater emphasis on equity capital and may impose a capital surcharge for systemically important financial institutions (SIFI). See Borak and Adler (2011).

allocation between the two. Thus, the determination of the optimal level of capital involves more than just the interest rate on deposits and the marginal cost of adjusting capital. Given that H and L are positively related to $(r_H - r_D)$ and $(r_L - r_D)$, respectively, it is not surprising that the optimal capital level is also positively related to the interest rate spreads.

Besides explicitly linking H and L to K, the results from equations (12) through (15) also highlight the importance of the structure of the regulatory capital standards on the allocation of assets and the level of capital. Specifically, the results reveal how the risk weight category an asset is slotted in under risk-based capital standards, $\varepsilon_H w_{I-H}$ and $\varepsilon_L w_{I-L}$ for high-risk and low-risk assets, respectively, and the minimum required risk-based capital ratio, d , influence not only how the balance sheet is allocated between H and L, but also how much capital banks hold and their use of deposits. Given that the risk weights in the standards contain errors, the errors in the risk weight also appear to play an important role in the optimal allocation of assets as well as capital. Here the subscript E denotes that the optimal values of H, L, D, and K when the risk weights are measured with error.

Alternatively, in cases where the internal models are used to assess the risk in an asset position (subscript I):

$$H_I^* = \frac{g(r_H - (1 - d w_{I-H})r_D) + d^2 w_{I-L} k (w_{I-L}(r_H - r_D) - w_{I-H}(r_L - r_D))}{fg + d^2 (gk w_{I-H}^2 + fk w_{I-L}^2)} \quad (16)$$

$$L_I^* = \frac{f(r_L - (1 - d w_{I-L})r_D) + d^2 w_{I-H} k (w_{I-H}(r_L - r_D) - w_{I-L}(r_H - r_D))}{fg + d^2 (gk w_{I-H}^2 + fk w_{I-L}^2)} \quad (17)$$

$$D_I^* = \frac{g(1-dw_{I-H})(r_H - (1-dw_{I-H})r_D) + (f(1-dw_{I-L})(r_L - (1-dw_{I-L})r_D))}{fg + d^2(gkw_{I-H}^2 + fkw_{I-L}^2)} - \frac{d^2k(w_{I-H} - w_{I-L})(w_{I-L}(r_H - r_D) - w_{I-H}(r_L - r_D))}{fg + d^2(gkw_{I-H}^2 + fkw_{I-L}^2)} \quad (18)$$

$$K_I^* = \frac{d(gw_{I-H}(r_H - r_D) + fw_{I-L}(r_L - (1-dw_{I-L})r_D) + dgw_{I-H}^2r_D)}{fg + d^2(gkw_{I-H}^2 + fkw_{I-L}^2)} \quad (19)$$

Clearly, errors in the risk weights may result in deviations from an optimal balance sheet allocation as they encourage underinvestment in cases where the risk weights are too high, relative to the capital required by the bank's internal risk assessment, and encourage overinvestment in cases where the risk weights are too low (Office of the Comptroller of the Currency, 1998). In our model, the impact of ε_H and ε_L on the balance sheet is easily noted by the general results⁶:

$$\Delta H = H_E - H_I \neq 0 \quad (20)$$

$$\Delta L = L_E - L_I \neq 0 \quad (21)$$

$$\Delta K = K_E - K_I \neq 0 \quad (22)$$

$$\Delta D = D_E - D_I \neq 0 \quad (23)$$

Despite the simplicity of our model, equations (20) through (23) can be thought of as the cherry-picking form of regulatory capital arbitrage, as the bank responds to errors in the regulatory capital requirement by altering its level of assets, deposits, and capital.

⁶ The equations in this study are solved for using Mathematica. Despite the simplicity of the model, the results of equations (20) – (23) are exceedingly complex polynomials, even when simplified. Therefore the results are not reported here but are available from the corresponding author.

To understand the impact of errors in the risk weights on bank balance sheet allocation, and the implications of those errors for the design of regulatory capital requirements, we compare the balance sheet of banks when errors are present in the risk weights (equations (12) – (15)) with the optimal balance sheet allocation when risk weights do not contain errors (equations (16) - (19)). We evaluate equations (12) through (23) by simulating the model.

3.2.1 Simulation results

For the purpose of simulating the model, the high-risk loan (H) is assumed to carry a CCC rating while the lower risk asset (L) is assumed to be a BBB-rated loan.⁷ Catarineu-Rabell, Jackson and Tsomocos (2005) find that about 3 percent of corporate exposures by U.S. banks are rated CCC and 29 percent are BBB rated. Furthermore, following Resti and Sironi (2007) the appropriate risk-weight category on BBB-rated credits from banks' internal models is assumed equal 75 percent, while following Altman and Saunders (2001), the risk-weight category on the CCC-rated exposure is assumed equal to 150 percent.

With regard to adjustment costs, they are unobservable. So following previous research by Kopecky and VanHoose (2004, 2006) and Jacques, Thornton, and Coadari (2010), the adjustment cost parameter estimates are derived from earlier research by Elyasiani, Kopecky and VanHoose (1995). Parameter estimates for f , g , and k are set at 0.04, 0.02, and 0.8, respectively. Setting adjustment costs for high-risk loans at 0.04 is similar to the upper limit used by Kopecky and VanHoose (2004), while setting

⁷ Similar to Peek and Rosengren (1995), it is assumed that banks hold only loans in their portfolios as loan rates are high enough relative to the rates on securities that banks choose to hold only loans.

adjustment costs for lower-risk loans at 0.02 assumes lower risk loans may not be subject to the same degree of monitoring and as a result have lower adjustment costs (Kopecky and VanHoose, 2006). In addition, adjusting equity may be costly for banks, particularly if they fail to meet the 8 percent risk-based capital ratio. Therefore, k is set at 0.8, the upper limit of the Kopecky and VanHoose range (2004). Finally, average interest rate data from the Federal Reserve Bank of St. Louis FRED database over the last 13 years reveals r_L equals 0.0653, r_H equals 0.1661, while interest rate data on r_D equals 0.0359.

Tables 1 and 2 provide results in the cases where the risk weight on only one of the assets is measured with error. In Table 1, the regulatory risk weight on H is assumed measured with error ($\epsilon_H \neq 1$). The top portion of Table 1 provides an example where the risk weight is too high ($\epsilon_H = 2.0$), this corresponding to a 300 percent risk weight category, a number consistent with the results of Resti and Sironi (2007) for a CCC credit. The lower portion of Table 1 provides an example where the risk weight on H is too low ($\epsilon_H = 0.67$), this example corresponding to the situation that existed with the 1988 Accord where CCC-rated corporate loans were slotted in the 100 percent risk weight category.

The second column of Table 1, in both the upper and lower portions of the table, reveal the simulated balance sheet allocation given the assumed interest rates, adjustment costs, a regulatory capital ratio of 8 percent and assuming no error in the risk weight category. We may think of this as the optimal balance sheet allocation as the regulatory capital standards mimic those of banks, with banks' allocation of assets and capital being the same under the risk-based capital standards as bank's internal model suggests.

The third column of Table 1 corresponds with the case where the regulator measures the risk weight with error as noted earlier. In the example in the top portion, H is assumed slotted in a 300 percent risk-weight category, but banks' internal models suggest that the 150 percent category is more appropriate. In this case, the risk weight on H being too high results in not only a dramatic decrease in H relative to bank's internal allocation ($\Delta H = -0.9965$), but also a reduction in L, the low-risk loan where there is no error in the risk weight. While banks increase capital under these circumstances ($\Delta K = 0.0561$), the level of capital is now above the level banks would have allocated based on their internal models. Furthermore, the risk weight on H being too high has resulted in a contraction of total lending ($\Delta(H+L) = -1.1311$). The increase in capital occurring at the same time as the decrease in lending is one of the results noted in some of the research on the 1988 Accord. This decrease in total lending is a form of regulatory capital arbitrage.

While normally thought of as solely occurring when banks exploit the risk-weights on assets being too low, in this case regulatory capital arbitrage and the decline in lending serve a signaling purpose by making regulators aware that the risk weight on H is out of line with banks' internal risk assessment. In contrast, column 3 in the lower portion of Table 1 provides an example where the risk weight category on H is too low. Here, when compared to the internal balance sheet allocation, banks not only overinvest in H, but also L, with total lending increasing by 0.4943. Furthermore, with the risk weight on H being incorrectly set by regulators, banks hold less capital than would be held in the no error case ($\Delta K = -0.0635$). This is the problematic regulatory arbitrage case where, because the risk weight is too low, banks have increased their holdings of the risky assets while also reducing the capital on the balance sheet.

Table 2 replicates Table 1, the difference here being that the error in the risk weight is attached to low-risk loans, while the risk weight on high-risk loans is assumed measured correctly. In this case, the internal risk weight category for L is assumed equal to 75 percent, this being consistent with findings by Resti and Sironi (2007). Similar to Table 1, in the top portion of Table 2, the regulatory capital standards are assumed to place too high a risk weight on the BBB exposure. Here, the risk weight is assumed equal to 100 percent, a result consistent with both the 1988 and revised Basel Accords. In the lower portion of Table 2, the risk weight assigned by regulators is assumed equal to 30 percent, a number consistent with results found by Altman and Saunders (2001). As before, column 2 shows the balance sheet allocation in the case where regulators and the bank assign the credit exposure to the same risk weight category, and the third column reveals the balance sheet allocation assuming an 8 percent risk-based capital ratio and the corresponding error in the risk weight. The results suggest that when the risk weight assigned by regulators to a low-risk asset is too high, banks respond by decreasing L, increasing H and decreasing K. With the exception of the change in capital ($\Delta K = -0.0029$), these changes are large relative to the internal balance sheet allocation shown in the second column. Furthermore, the results in the lower portion of Table 2 reveal a similar story. In this case, by setting the risk weight on L too low, banks respond by increasing both H and L and decreasing K. Again the magnitude of the changes appears large.

Taken as a whole, the results in Tables 1 and 2 suggest that errors by regulators in correctly setting risk weights on assets result in unintended consequences, including regulatory capital arbitrage, as not only is the level of bank capital incorrect relative to

the internal results, but total lending is also dramatically effected. More specifically, the simulated results suggest that inaccuracies in assigning the correct risk weight categories to assets in risk-based capital standards results in not only significant deviations of lending from the levels banks would undertake based on their internal risk systems, but also, in some cases, a contraction in the amount of capital in the banking system. Given the continued reliance of regulators on risk weights in a building-block approach to regulatory capital standards, the simulated results suggest that unintended consequences, including regulatory capital arbitrage, will continue to exist.

4. The Response of Regulators

The results of the previous section note that, even in the simple case where only one asset in banks' balance sheets contain an error in its risk weight, banks' balance sheets deviate from the balance sheet they would choose based on their internal risk systems. Obviously, in terms of minimizing the unintended consequences of bank capital regulations, the first-best solution is for the design of regulatory capital requirements to mimic banks' internal risk models. But past efforts at using the results of banks' internal models have been limited, and even the advanced internal ratings based approach of Basel II does not fully utilize internal models. As a result, if bank regulators are to minimize the unintended consequences of regulatory capital standards, they must address two types of balance sheet problems: a deviation of bank capital from its internally estimated economic capital levels, and deviations of total bank lending from its optimal level.

Assuming bank regulators will not fully adopt bank's internal models for establishing regulatory capital requirements, and that the errors contained in the risk weights assigned by regulators under risk-based capital standards continue to exist, the question becomes what steps regulators can take to minimize the unintended consequences of such regulations. In light of the recent financial crisis, and one possible answer, is that some observers have begun to question the time-invariant nature of minimum capital requirements. As discussed in the literature, regulators could alter the risk-based capital ratio, d , so as to minimize the unintended consequences associated with regulatory capital standards. Specifically, d could be either increased or decreased from 8 percent. This is similar to the family of point-in-time risk curves proposed by Kashyap and Stein (2004) to minimize the effects of procyclicality in Basel II, and the time-varying capital ratios of Kashyap, Rajan, and Stein (2008), with the intention that bank capital be available to act as a rainy-day fund. In these cases, the capital ratio is not time invariant, but rather is reduced during difficult economic periods, such as recessions, and is raised during periods of economic growth. In addition, raising capital ratios above the 8 percent minimum is both permissible under the current risk-based capital rules and is often used by regulators in taking more formal actions against problem banks, such as memorandums of understanding.

4.1 Minimizing Capital Discrepancies

Given the unintended consequences of regulatory capital standards noted earlier, one possibility is that, in order to maintain the safety and soundness of the banking system, regulators may choose to try to minimize the deviations of capital from the levels

suggested by banks' internal risk systems, as mistaken levels of capital misallocate an expensive source of funding. On the part of regulators, this goal is similar in nature to current attempts by regulators to implement the more risk sensitive Basel II standards while maintaining the level of capital in the banking system. In that sense, solving $\Delta K = K_E^* - K_I^* = 0$ for d implies an optimal capital ratio, similar in nature to Barrios and Blanco (2003), with the difference here being that optimality is not from the perspective of the banks, but rather from the perspective of regulators who seek to minimize the unintended consequences associated with risk-based capital standards.

To gain insight into whether regulators can use the risk-based capital ratio to minimize deviations of capital from banks' internal levels, the fourth column of Tables 1 and 2 present simulated results. Here the regulator sets d so that $\Delta K = 0$, in essence making K_E equal to K_I . With regard to an error in the risk weight on H and L, the results in column 4 of Table 1 suggest that, if the risk weight is too high, lowering the risk weight to 4.2 percent will bring the capital back in line with K_I . Interestingly enough, in the top portion of Table 2, the results suggest that if the risk weight on L is too high, the capital ratio needs to be raised, not lowered, in order to maintain the level of capital in the banking system. This result is a function of the fact that when the risk weight on L is too high, banks substitute out of L and into H, thereby increasing their relative holdings of the risky asset. With regard to the cases where the risk weight on H and L are too low, the results in the bottom portions of Tables 1 and 2 suggest that regulators can maintain the level of capital in the system by raising d to 8.57 percent in the case where $\varepsilon_H = 0.40$ and raising d to 12.8 percent in the case where $\varepsilon_L = 0.67$.

While the risk-based capital ratios implied by this simulation exercise are clearly within reasonable bounds for regulators, a few aspects of the results are troubling. First, and most obvious, using the risk-based capital ratio as a tool for maintaining the level of capital requires a knowledge on the part of regulators as to the adjustment costs banks face, as well as the magnitude of the errors that differentiate K_E from K_I . And given that banks' internal risk classifications systems will differ from each other (Treacy and Carey, 1998), such an analysis would need to be conducted on a bank-by-bank basis. In that sense, regulators would need to move away from the uniform minimum risk-based capital ratio, currently set at 8 percent of risk-weighted assets, and move toward a minimum risk-based capital ratio that is unique for each bank, given its internal risk classification system and its marginal costs of adjusting its balance sheet.

Second, the simulations are not consistent in the direction that regulators would necessarily need to change the risk-based capital ratio. The examples shown in Tables 1 and 2 are simple examples consistent with either regulatory experience with the risk-based standards or the existing research about appropriate risk weights for assets of different credit risk ratings. In particular, when the risk weight on an asset was too high, maintaining the level of capital was accomplished by reducing d when the error was in ε_H but by increasing d when the error was in ε_L .

Finally, altering d so as to maintain capital in the banking system resulted in a change in total lending with the change ranging from -0.4885 to 0.3644 depending on the nature, direction, and magnitude of the error. Such deviations in H and L raise the significant possibility that using d as a policy tool may have the unintended consequence of altering the level of lending, in general, and the composition of lending, in particular,

as increases or decreases in lending were not equally distributed between H and L in the simulations.

4.2 Minimizing Asset Misallocation

Alternatively, regulators worried about the macroeconomic implications of regulatory capital standards could choose d so as to minimize the misallocation of resources. This is consistent with the Kashyap and Stein (2004) argument that regulator's objective function includes a role for creating positive net present value loans. As noted earlier, evidence exists that implementation of the 1988 Basel Accord resulted in a dramatic decrease in commercial lending in the United States, a factor that contributed to the 1990-91 recession. Recognizing that errors are codified in the risk weights, but that regulators have some discretion in adjusting the risk-based capital ratio, the goal of minimizing asset misallocation can be accomplished by altering d such that $\Delta(H+L) = 0$.

To gain insight into whether the risk-based capital ratio can effectively be used to minimize asset misallocation, the fifth column of Tables 1 and 2 reveal that results of simulations when the risk weights contain errors and bank regulators objective is to make $\Delta(H+L) = 0$. The results suggest that when the risk weight on H is too high, reducing d to 4.92 percent will maintain the level of total lending while if the risk weight on L is too high, d is reduced to 7.24 percent. In cases where the risk weight is too low, raising d to 10.37 percent in the case of $\varepsilon_H = 0.67$ and to 10.39 percent in the case of $\varepsilon_L = 0.40$ maintains the total lending done by the bank.

The difficulty here however is that using the risk-based capital ratio to correct for unintended consequences is fraught with some of the same difficulties noted earlier. In

this case, the optimal value of d ranges from 4.92 percent, when $\varepsilon_H = 2.0$, to 10.39 percent, this occurring when $\varepsilon_L = 0.40$. As noted before, this requires an ability on the part of the regulator to be able to quantify banks' marginal adjustment costs, but also to know the nature, direction, and magnitude of the errors in the risk-based capital standards as they are applied to each particular bank. In addition, altering d so as to achieve $\Delta(H+L) = 0$ results in changes in the level of capital banks will choose to hold and that level of capital is not necessarily consistent with banks' internal economic capital calculations or regulators desire to maintain the level of capital in the banking system. In these cases, the simulations suggest that K_E will deviate from K_I by a range of -0.0230 to 0.0303. Finally, even if d is set so as to maintain total lending, the simulated results show that the composition of total lending has changed. And in some cases, an increase in high risk lending has occurred at the same time as a decrease in capital.

5. Errors in the Risk Weights on Both Assets

The earlier examples are simplified in assuming that only one of the assets in the risk-based capital standards contains an error at any point in time. More realistically, multiple assets are likely to contain errors in their risk weights at the same time as banks' internal risk rating systems often have 8 or more risk categories (Treacy and Carey, 1998), while even more recent changes in the Basel regulations, such as the standardized version of Basel II, contain only 5 risk weight categories. The simultaneous existence of errors in both risk weights, coupled with a desire by regulators to either maintain capital or minimize the misallocation of assets, raises additional problems for bank regulators.

In this case, the regulator has one policy tool, altering the risk-based capital ratio, but two goals to achieve.

In essence, the goals the regulator may be trying to achieve exceed the number of policy instruments available to achieve those goals. An example often associated with the 1988 Basel Accord is presented in Table 3. Under the 1988 risk-based standards, both H and L were slotted in the 100 percent risk weight category, a result that has been criticized for placing too low a risk weight on H and too high a risk weight on L. Again assuming that banks' internal risk allocation system suggest w_{I-H} equals 150 percent and w_{I-L} equals 75 percent, ε_H equals 0.67 and ε_L equals 1.33, banks, optimizing their balance sheets as shown in column 3, results in an increase in high-risk loans ($\Delta H = 0.3390$), a decrease in low-risk loans ($\Delta L = -0.0434$) and a decrease in capital ($\Delta K = -0.0616$). Regulators, desiring to minimize the unintended consequences of capital regulations, may choose to alter d so as to either maintain capital (column 4) or maintain total lending (column 5). The results in the two-error-in-risk-weight case are even more troubling than those found in Tables 1 and 2. If regulators choose to maintain capital, then an increase in the risk-based capital ratio becomes necessary. But given that the risk weight on L is too high to begin with, in our simulations, increasing d above 12.99 percent results in banks completely abandoning low-risk loans while still experiencing a decrease in K. Alternatively, the simulations suggest that increasing d to 9.30 percent will maintain the level of bank lending, but in this case, given the complexity of having two errors in the risk weights, results in an increase in H and a decrease in K from the internal level.

6. Policy Implications

In recent decades, bank regulators have become increasingly reliant upon quantitative regulatory capital standards as a means of not only explicitly incorporating risk into regulatory capital requirements, but also ensuring that banks hold capital commensurate with that risk. The risk-based capital standards, from the 1988 Accord through the current Basel II standards, have relied upon a building block approach to capital through the use of risk weights assigned to assets and off-balance sheet activities. Despite enhancements to improve the accuracy of risk-based capital standards, they continue to result in unintended consequences, as the use of risk weights brings with it errors in the measurement of risk. Given the ongoing efforts by bank regulators to quantitatively assess regulatory capital, this study asks whether it is necessary for regulators to accurately assess risk weights in the risk-based capital standards.

Our results suggest that despite enhancements by regulators to improve the accuracy of risk-based capital requirements, unintended consequences will continue. Unintended consequences, including regulatory capital arbitrage, occur because the risk weights used in regulatory capital standards are blunt instruments that may only loosely resemble the internal risk assessments banks assign to their credit exposures. In that sense, similar to Mingo (2000), the optimal regulatory policy is one where regulatory capital standards effectively mimic banks' economic capital requirements. The complete adoption by bank regulators of banks' internal risk models as a means of establishing regulatory capital requirements, while a first-best option in terms of getting the risk weights correct, is unlikely to happen in the near term given concerns about credit risk data (Herring, 2005), experience from the recent financial crisis, and the inertia and politics associated with negotiating international regulatory capital standards.

Given regulators' reliance on risk weights, this implies that enhanced bank supervision (Pillar 2) must play a critical role in the regulatory process, particularly for those banks who are likely to engage in regulatory capital arbitrage (Pelizzon and Schaefer, 2006). Such a process will be difficult however, as Kaufman (2004) points out, because internal bank models may be so complex as to make supervisory validation for accuracy highly unlikely. Furthermore, given that banks' ability to game the system will not be prevented under the more recent versions of the Basel Accord (Shadow Financial Regulatory Committee, 2001), a minimum leverage ratio, independent of risk, should be maintained so as to ensure a floor of bank capital (Bischel and Blum, 2005; Blum, 2008). Given the limited ability of quantitative regulatory capital requirements to ensure capital adequacy, this also suggests a possible role for additional market discipline.

Finally, some recent literature has proposed the use of the risk-based capital ratio as a tool for improving the effectiveness of regulatory capital requirements. Such discussion has come in the form of time-varying risk-based capital ratios that may be raised or lowered depending upon economic circumstances (Kashyap and Stein, 2004; Kashyap, Rajan and Stein, 2008). The results of this study suggest that using the risk-based capital ratio as a policy tool to solve the problems associated with errors in the risk weights is unlikely to solve the problems of unintended consequences or regulatory capital arbitrage. For such a system to be effective, regulators would need to understand both the direction and magnitude of the errors in the risk weights, on a bank-by-bank basis, as well as the marginal adjustment costs associated with the elements of a bank's balance sheet. Given that the risk-based capital ratio is but one tool, and that errors may

exist in multiple risk weights as well as the unintended consequences of bank regulation may take multiple forms, consistent with Pelizzon and Schaefer (2006), we find the risk-based capital ratio to be an ineffective tool.

Table 1

**Errors in Risk Weights on High-Risk Asset (H)
(L rated BBB, H rated CCC)**

Risk Weight Too High ($\varepsilon_H = 2.0$):

Variable	$\varepsilon_H = 2.0$		$\Delta K = 0$	$\Delta H+L = 0$
	$\varepsilon_H = 1$	$\varepsilon_H = 2.0$	$\varepsilon_H = 2.0$	$\varepsilon_H = 2.0$
d	0.08	0.08	0.0420	0.0492
H	2.5278	1.5313	2.4923	2.2853
L	0.7428	0.6081	1.0886	0.9851
D	2.9226	1.7354	3.2330	2.8969
K	0.3479	0.4040	0.3479	0.3735
ΔH		-0.9965	-0.0335	-0.2425
ΔL		-0.1346	0.3459	0.2424
$\Delta(H+L)$		-1.1311	0.3104	0.0000
ΔD		-1.1872	0.3104	-0.0257
ΔK		0.0561	0.0000	0.0256

Risk Weight Too Low ($\varepsilon_H = 0.67$):

Variable	$\varepsilon_H = 0.67$		$\Delta K = 0$	$\Delta H+L = 0$
	$\varepsilon_H = 1$	$\varepsilon_H = 0.67$	$\varepsilon_H = 0.67$	$\varepsilon_H = 0.67$
d	0.08	0.08	0.1280	0.1037
H	2.5278	2.8698	2.4755	2.6715
L	0.7428	0.8951	0.3065	0.5991
D	2.9226	3.4804	2.4341	2.9456
K	0.3479	0.2844	0.3479	0.3249
ΔH		0.3420	-0.0523	0.1437
ΔL		0.1523	-0.4362	-0.1437
$\Delta(H+L)$		0.4943	-0.4885	0.0000
ΔD		0.5578	-0.4885	0.0230
ΔK		-0.0635	0.0000	-0.0230

In these simulations, $r_L = .0653$, $r_H = .1661$, $r_D = .0359$, $f = 0.04$, $g = 0.02$, $a = 0$, $k = 0.8$, $\varepsilon_L = 1$, $w_{I-L} = 0.75$, and $w_{I-H} = 1.50$.

Table 2

**Errors in Risk Weight on Low-Risk Asset (L)
(L rated BBB, H rated CCC)**

Risk Weight Too High ($\varepsilon_L = 1.33$):

Variable	$\varepsilon_L = 1$		$\Delta K = 0$	$\Delta H+L = 0$
	$\varepsilon_L = 1$	$\varepsilon_L = 1.33$	$\varepsilon_L = 1.33$	$\varepsilon_L = 1.33$
d	0.08	0.08	0.0820	0.0724
H	2.5278	2.5347	2.5097	2.6308
L	0.7428	0.5120	0.4787	0.6398
D	2.9226	2.7016	2.6406	2.9385
K	0.3479	0.3450	0.3978	0.3321
ΔH		0.0069	-0.0181	0.1031
ΔL		-0.2308	-0.2640	-0.1029
$\Delta(H+L)$		-0.2239	-0.2821	0.0001
ΔD		-0.2210	-0.2820	0.0159
ΔK		-0.0029	0.0000	-0.0158

Risk Weight Too Low ($\varepsilon_L = 0.40$):

Variable	$\varepsilon_L = 1$		$\Delta K = 0$	$\Delta H+L = 0$
	$\varepsilon_L = 1$	$\varepsilon_L = 0.40$	$\varepsilon_L = 0.40$	$\varepsilon_L = 0.40$
d	0.08	0.08	0.0857	0.1039
H	2.5278	2.5575	2.4763	2.2161
L	0.7428	1.1910	1.1585	1.0544
D	2.9226	3.4131	3.2870	2.8923
K	0.3479	0.3355	0.3479	0.3782
ΔH		0.0298	-0.0514	-0.3117
ΔL		0.4483	0.4158	0.3117
$\Delta(H+L)$		0.4780	0.3644	0.0000
ΔD		0.4904	0.3643	-0.0303
ΔK		-0.0124	0.0000	0.0303

In these simulations, $r_L = .0653$, $r_H = .1661$, $r_D = .0359$, $f = 0.04$, $g = 0.02$, $a = 0$, $k = 0.8$, $\varepsilon_L = 1$, $w_{I-L} = 0.75$, and $w_{I-H} = 1.50$.

Table 3**Errors in Risk Weights on Both High-Risk (H) and Low-Risk (L) Assets
(L rated BBB, H rated CCC)**

<u>Variable</u>	<u>$\varepsilon_L, \varepsilon_H = 1$</u>	<u>$\varepsilon_H = 0.67$ $\varepsilon_L = 1.33$</u>	<u>$\Delta K = 0$</u>	<u>$\Delta H + L = 0$</u>
d	0.08	0.08	0.1299	0.0930
H	2.5278	2.8668	2.5148	2.7678
L	0.7428	0.6994	0.0006	0.5028
D	2.9226	3.2799	2.1870	2.9652
K	0.3479	0.2863	0.3284	0.3054
ΔH		0.3390	-0.0130	0.2400
ΔL		-0.0434	-0.0180	-0.2399
$\Delta(H+L)$		-0.2957	-0.7551	0.0000
ΔD		0.3573	-0.7356	0.0426
ΔK		-0.0616	-0.0195	-0.0425

In these simulations, $r_L = .0653$, $r_H = .1661$, $r_D = .0359$, $f = 0.04$, $g = 0.02$, $a = 0$, $k = 0.8$, $\varepsilon_L = 1$, $w_{I-L} = 0.75$, and $w_{I-H} = 1.50$.

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