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Capital Requirements for Securities Firms

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ABSTRACT

Regulatory authorities set capital requirements to cover the position risk of securities firms and to protect against losses arising from fluctuations in the value of their holdings. The requirements may be set using the comprehensive approach required by the U.S. Securities and Exchange Commission, the building-block approach required by the European Community, or the portfolio approach required by the United Kingdom. We compare these three alternatives using a large sample of U.K. equity trading books. The portfolio approach systematically specifies larger requirements for riskier books, and vice versa. It is more efficient than the building-block approach, and far more efficient than the comprehensive approach.

POSITION RISK ARISES FROM the exposure of financial institutions to fluctuations in the prices of securities in which they hold positions as principals. If prices move adversely, firms may be able to unwind their positions only by accepting a loss. Provided they have (or have access to) sufficient capital, there need not be a consequential loss for the firm's clients. The capital structure of a securities firm is therefore a matter of potential importance to its clients, since the greater the proportion of equity, the lower the risk of default.

Securities firms' capital structures are also of importance to regulatory authorities, who are concerned about systemic risk and the negative externalities that can arise from defaults. National regulatory authorities throughout the world have therefore for many years imposed minimum capital requirements (see Steil (1994)). Recently, there has been a growing pressure towards global harmonization. However, despite extensive negotiations, banking and securities regulators have failed to reach international agreement on standardized capital ratios. The debate has been highly political, and one of the

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most contentious issues has been the capital required to cover equity position risk. This forms the central topic of this article.

Capital requirements should clearly reflect the risk, or volatility, of the firm's trading book. A firm's book of equity positions is, of course, a portfolio. We know from portfolio theory that firms with well diversified portfolios of positions are subject to lower risk than firms with concentrated books. Furthermore, since trading books, unlike a typical fund manager's portfolio, contain short as well as long positions, it is also clear that balanced books—because they tend to hedge out market risk—are generally less risky than all-long (or short) books. One would expect any system for setting capital requirements to recognize these basic tenets of portfolio theory, and to draw heavily on existing knowledge of this field to link portfolio position risk explicitly to capital requirements. In other words, an appropriate system would be one that adopts a portfolio approach.

Unfortunately, the system for equity position risk requirements that emerged as the front-runner in the process of international negotiations between regulators is the so-called building-block approach, and this does not meet even this simple test. Worse still, the portfolio approach has been explicitly rejected, despite the fact that a variant of this approach, based on using a simplified version of the Markowitz model to estimate portfolio variance, has been tried and tested in the United Kingdom and has formed the basis for setting British capital requirements since the 1988 Financial Services Act.

Elimination of the portfolio approach represents a serious backward step, since it means that the proposed basis for setting capital requirements not only ignores established financial research, but fails to reflect good current practice.[1] However, at the time of writing, international regulators have yet to reach final agreement. The financial services industry is therefore not yet fully committed to the imposition of a worldwide framework that would provide perverse incentives for securities businesses, and that would fail to encourage prudence among institutions such as market makers, broker dealers, and banks acting as principals in the securities markets.

This article sets out to justify and demonstrate these claims. In the following section, we discuss the nature of capital requirements, and why they are imposed on securities firms. In Section II, we then outline the competing systems for setting capital requirements. We compare these approaches using a large sample of U.K. equity trading books, which are described in Section III. We explain our research design in Section IV and present our main results in Section V. In Section VI, we discuss the impact of the choice of parameter values and explore whether there is scope for improving the effectiveness of each of the competing systems. We conclude with a summary and discussion in Section VII.

[1] Risk measurement models that utilize portfolio theory are even distributed free of charge, and the required databases are posted daily on the Internet; see Guldimann (1994, 1995).

I. The Imposition of Capital Requirements

A. Rationale for Capital Requirements

The choice of financial structure is a strategic decision for most firms. However, there is an interesting contrast between financial and nonfinancial firms. Nonfinancial companies choose the debt/equity ratio they prefer, and their choice is not normally overridden by regulators specifying maximum leverage limits. Implicitly, competition is assumed to generate appropriate capital structures, and financial distress costs are an integral part of the decision process. Most countries take a different approach for financial businesses, however. The systemic costs of default, such as the negative externalities from a banking panic, have persuaded regulators to impose minimum capital requirements. These are designed to lower the chances of failure, and hence the expected social costs of failure.[2]

An obvious question is what constitutes an "acceptable" level of failure? Or more fundamentally, if failures can impose social costs, why not set capital requirements so high that default risk is effectively eliminated? It might be argued that high capital requirements would not impose costs on securities firms, since they could place "surplus" capital on deposit and thereby earn the market rate of interest. Indeed, one might invoke the Modigliani and Miller (MM) (1958) propositions to argue that a firm's weighted average cost of capital is independent of its capital ratio.

In practice, there are many reasons why the MM assumptions may not hold, including taxes, flotation/transactions costs, and agency costs. Certainly practitioners, and indeed, even regulators argue strongly that additional capital is costly since the weighted average cost of capital increases with the capital ratio (see Schaefer (1992)). The implication here is that the optimal private level of debt that firms would otherwise select is greater than the maximum level permissible under the capital requirement rules. There is thus a strong belief that such requirements impose real costs on securities firms—and ultimately on their clients. Capital adequacy rules could also increase investors' costs by impacting on competition. For example, if requirements are set too high, this could create entry barriers that reduce the potential for competition among securities firms (see Office of Fair Trading (1988)).

Regulations on capital requirements should therefore reflect several tradeoffs. The costs of imposing requirements, and any impact these have on competition, need to be weighed against the costs of default. Given this tradeoff, it cannot be desirable to eliminate default risk, only to control it. The optimal capital structure from a social viewpoint will consequently

[2] See Stigler (1971) and Peltzman (1976) for the classic arguments against regulation, and Dewatripont and Tirole (1994) for an excellent review in the context of banking institutions. For a review of the theory of capital structure and related evidence see Harris and Raviv (1991). The case for financial regulation to cover systemic risks in securities markets is presented in Hewitt (1991) and Steil (1994), and the costs incurred as a result of the regulatory system are estimated in Franks and Schaefer (1995) and are reviewed in Brealey (1995).

expose society to at least some risk. In other words, some limited risk of default by securities firms is acceptable (and is, in any case, probably inevitable).[3] In practice, therefore, capital requirement rules focus on controlling default risk for investors.

B. The Components of Capital Requirements and Position Risk

Default by a securities firm could be triggered many events. A firm could become (at least technically) insolvent by making inadequate provision for working capital. Alternatively, default could be triggered by the failure of a major counterparty, or by substantial losses on its securities positions.[4] In most countries, capital requirements are specified to embrace these different risks. For example, in the United Kingdom, the total capital requirement laid down under the Securities and Futures Authority (1992) rulebook is broken down into three components: a primary requirement, essentially to cover working capital; a counterparty risk requirement; and a position risk requirement (PRR). For large, active securities firms, the PRR is by far the most important of these, and it is this component that we analyze in this article.

Clearly, the amount of capital needed by a securities firm to ensure an acceptably small probability of failure depends on the risk of the portfolio of security positions it holds. The regulations need to be designed so that, even if investors use the services of a securities firm with substantial risk exposure, the firm's capital will be sufficient to cover the chance of loss with an acceptably high degree of probability. The positions held by a securities firm may embrace both domestic and international securities, and may include debt positions, options, swaps, and futures, and hedging transactions as well as equities. While regulators set PRR requirements to cover *all* of a firm's positions, these are typically set in a compartmentalized fashion with debt position risk,[5] for example, calculated separately from equity position risk, and with little or no regard to cross-correlations between asset categories. While this article focuses on equity position risk, the issues we raise about the importance of adopting a portfolio approach obviously have wider implications for the firm's overall portfolio of positions across all asset classes, a point which is explored further in Merton (1995).

In setting requirements for equity position risk, the rules should reflect three factors. First, they should reflect the risk, or volatility, of the firm's trading book. Second, sufficient capital should be posted to cover monitoring lags or regulatory delays in responding to rule violations. And third, capital is

[3] This is clearly recognized by the regulatory authorities. For example, the U.K.'s Securities and Investments Board (1987) explains its capital adequacy rules as follows: "The primary objective... is to ensure that the risks which a firm undertakes are not disproportionate to its resources. It is *not* that there would be complete confidence that a market participant will *never* default, but that the size and frequency of any failures should not have material systemic consequences and that the risk of loss to retail investors... should be small."

[4] Calomiris and Gorton (1991) conclude that, in the case of banking institutions, default is in most cases linked to a decrease in the value of the firm's assets.

[5] See Brealey and Rowley (1989) and Dermine (1991) for a discussion of debt position risk.

needed to cover the time to trade out of positions in the book, which in turn depends on the liquidity of the securities held. The PRR thus needs to be a function of both the book's risk and the period for which the firm could be "at risk."

For this reason, most systems for setting equity PRRs impose a basic PRR to cover the risk of the book and to allow for the delay required until positions in the most liquid stocks are closed out. They then superimpose a supplementary requirement for any less liquid securities, to cover the additional time needed to trade out of these.[6] Our concern here is not with the efficacy of such liquidity adjustments, nor even with the absolute levels of capital required and whether these are adequate to allow for likely delays. Instead, we are concerned with the central issue of whether the system chosen for setting the basic position risk requirement results in PRRs that reflect as closely as possible the risks involved.

II. Alternative Systems for Setting Position Risk Requirements

A. The Competing Systems

Capital requirements may be set using one of a number of competing methods. The three main contenders are the comprehensive approach, as applied in the United States by the Securities and Exchange Commission (SEC); the building-block approach, as proposed by the international Basle Committee on Banking Supervision, and incorporated in the European Commission's (1993) capital adequacy directive (CAD) due to take effect in 1996; and the portfolio approach, which in the United Kingdom forms part of the rules of the Securities and Futures Authority (1992). These three systems generate quite different capital requirements for a given portfolio.

In theory, since the portfolio approach sets capital requirements by direct reference to an estimate of portfolio variability, it ought to be the best procedure. In practice, however, the version of this approach applied by U.K. regulators is based on a set of strong simplifying assumptions. We therefore refer to this as the "simplified portfolio approach." If the assumptions underlying this approach are realistic, then its capital requirements should correlate closely with the true volatility of the portfolio of positions. But if the assumptions are unrealistic, the correlation may be low or nonexistent, and ad hoc methods, such as the comprehensive or building-block approaches,

[6] The definitions of liquidity commonly used in assessing capital requirements for less marketable securities are invariably based on ad hoc classifications. We are not aware of any country where the liquidity adjustment is linked to a security's infrequency of trading. Securities firms could almost always trade out of positions even in very illiquid stocks at *some* price. The price of immediacy, however, may be very high, and almost certainly higher than the notional spreads used in marking such positions to market. By waiting, it should be possible to obtain better average prices, and it is in this sense that firms require more time to trade out of illiquid stocks.

could conceivably perform better. In describing the three competing systems, it nevertheless makes sense to start with the simplified portfolio approach, since this is the only method that has a direct lineage with theory.

B. The Simplified Portfolio Approach

Markowitz (1952) long ago demonstrated that the risk, or variance, σ^2, of an equity portfolio is given by:

$$\sigma^2 = \sum_i \sum_j w_i w_j \sigma_{ij} \tag{1}$$

where w_i and w_j are the proportions of the net value of the portfolio invested in assets i and j, and σ_{ij} is the covariance of returns between assets i and j.

Equation (1) could in principle be used directly to estimate the variance of a portfolio of equity positions. As is well known, however, the onerous data requirements, coupled with the problems of estimate error, have led to various simplifications, the best known of which is Sharpe's (1963) market model. This makes the simplifying assumption that the returns on securities are related only through a common relationship with a single, underlying "market" factor, so that portfolio variance is given by:

$$\sigma^2 = \left(\sum_i w_i \beta_i \right)^2 \sigma_m^2 + \sum_i w_i^2 \sigma_{\varepsilon i}^2 \tag{2}$$

where σ_m^2 is the variance of the market, β_i is the beta of security i, and $\sigma_{\varepsilon i}^2$ is security i's residual variance. This approximation offers considerable economies in terms of data requirements, reducing the number of parameter estimates required for a population of, say, 2000 stocks from just over two million with the Markowitz model, to just over 4000.

The simplified portfolio approach used by U.K. regulators is based on equation (2), but involves a further simplification which reduces the portfolio variance formula to reliance on just two market-wide parameters. This is achieved by assuming (i) a beta of unity and (ii) an identical residual variance of σ_ε^2 for all securities.[7] Equation (2) then becomes:

$$\sigma^2 = \sigma_m^2 + \sigma_\varepsilon^2 \sum_i w_i^2 \tag{3}$$

We noted above that PRRs should not only reflect the variance of the portfolio of positions, σ^2, but also the period during which the firm could be at risk, and the "acceptable" probability of default. U.K. regulators have taken the

[7] An alternative simplification, also requiring just two parameters, would be for all securities to have the same variance of returns and the same pairwise correlation of returns (see Elton and Gruber (1995)).

view that, for the most liquid group of securities, the time interval should notionally be one week,[8] coupled with a confidence interval of 95 percent. The PRR is thus set equal to twice the weekly standard deviation of returns:

$$PRR_p = 2\sigma = 2\sqrt{\left(\sigma_m^2 + \sigma_\varepsilon^2 \sum_i w_i^2\right)} \tag{4}$$

where PRR_p is the PRR expressed as a percentage of the net value of the book, and σ_m^2 and σ_ε^2 are the one-week variances of market returns and of average residual returns for the equity market in question.[9] For a portfolio of the most liquid category of U.K. equities, for example, the parameters used are $\sigma_m^2 = 6.75$ and $\sigma_\varepsilon^2 = 21.5$ (equivalent to $\sigma_m = 18.7$ percent and $\sigma_\varepsilon = 33.4$ percent on an annualized basis[10]). Further adjustments are then made for less liquid securities, and for books which are diversified across different national markets.[11]

[8] The most liquid group of securities currently comprises the FT-SE 100 Index constituents (the largest 100 stocks) in the United Kingdom, the Nikkei 225 Index constituents in Japan, and the Standard and Poor's 500 Index constituents for the United States. It is hard to argue that securities firms require a week to trade out of positions in such stocks. Within the U.K., for example, FT-SE 100 stocks have average nontrading intervals of much less than one tenth of a day (see Dimson and Marsh (1994)). More anecdotally, as one equity trader is reported as saying in Lee (1992), "They (international bank regulators) do not seem to understand that we do not buy ICI on a Wednesday and sell it on a Thursday. We buy and sell ICI 20 times in a single day." The one-week assumption thus needs to be viewed not so much as the time required to trade out of such positions, but more as an allowance for regulatory delays in identifying and responding to rule violations.

[9] Under the U.K. capital adequacy regulations (Securities and Futures Authority (1992)), this formula is referred to as Equity Method 2. Firms can use this if they meet a "diversification test" for their holdings in the country in question. For the United Kingdom, United States, and Japan, they must hold at least ten long or short positions, while for other countries, they must hold at least five positions. For countries where they have fewer positions, they are obliged to use Equity Method 1, which affords no capital reductions for diversification, and effectively assumes that $\Sigma_i w_i^2 = 1$.

[10] The parameter values used differ between national equity markets and are based on historically estimated market and average residual return variances for each market. Since the required confidence interval is two standard deviations, all variance parameters given in the Securities and Futures Authority (1992) rulebook are expressed as $(2\sigma)^2 = 4\sigma^2$. Thus the two parameters for the UK market are given as $A = 27$ ("country adjustment") and $B = 86$ ("country factor"), where $A = 4\sigma_m^2 = 27$ and $B = 4\sigma_\varepsilon^2 = 86$, i.e., $\sigma_m^2 = 6.75$ and $\sigma_\varepsilon^2 = 21.5$ as cited above. These parameters, A and B, are then substituted into the formula $PRR_p = \sqrt{(A + B \Sigma_i w_i^2)}$, namely into a slightly rearranged version of equation (4), where the "2" is taken inside the square root operator as $2^2 = 4$.

[11] Under the U.K.'s simplified portfolio approach, securities are divided into three liquidity bands. For a highly liquid book invested entirely in FT-SE 100 Index constituents, no liquidity adjustment is required to equation (4) above; for a portfolio invested entirely in the least liquid group of securities, however, the capital requirements given by equation (4) would be trebled. The U.K. capital adequacy rules also recognize the benefits of international equity diversification by giving an allowance for diversification *across* country portfolios of qualifying U.K., U.S., and Japanese securities, based on the estimated cross-correlations between these three markets. This is referred to in the regulations as Equity Method 3 (see Securities and Futures Authority (1992)).

A considerable strength of the simplified portfolio approach is that it ensures that capital requirements are lower both when trading books are well diversified, and also when they are balanced. This can be seen by rewriting equation (4) as:

$$PRR_s = 2\sqrt{\left(\sigma_m^2 b^2 + \sigma_\varepsilon^2 \sum_i p_i^2\right)} \tag{5}$$

where PRR_s is the PRR under the simplified portfolio approach, expressed now as a percentage of the *gross* book; p_i is the value of the holding in security i, also expressed now as a proportion of the value of the gross book; and $b = \Sigma_i\, p_i$ is the ratio of the net to the gross value of the trading book.

The impact of diversification can be seen first by considering the case of an all long (or short) book, where $b = 1$. If the entire book is invested in a single security, then $\Sigma_i\, p_i^2 = 1$, and the book has the same risk as a portfolio invested in a typical single security, i.e., $\sigma^2 = \sigma_m^2 + \sigma_\varepsilon^2$. But when the number of holdings is large, $\Sigma_i\, p_i^2$ becomes small, signifying that residual risk has been largely diversified away, reducing the portfolio variance to $\sigma^2 \approx \sigma_m^2$, so that correspondingly less capital is required. $\Sigma_i\, p_i^2$ is thus a measure of the book's concentration, and is analogous to the Herfindahl index used to estimate industrial concentration. Sharpe (1970) shows that under the assumptions of the simplified diagonal model, this measure, when expressed in numbers-equivalent form as $n = 1/\Sigma_i\, p_i^2$, has a direct interpretation as a proxy for diversification. Specifically, a portfolio with a Sharpe's diversification measure of n has the same residual risk as a portfolio with n equal-sized holdings of average risk stocks.

Equation (5) also ensures reduced capital requirements for balanced books. In books where long positions are largely balanced by short positions (or vice versa), then b, the ratio of the net to the gross value of the book, becomes small. Equation (5) shows that, when b is small, the market risk of the book is largely hedged away, reducing the portfolio variance (effectively) to $\sigma_\varepsilon^2\, \Sigma_i\, p_i^2$. If the book is also well diversified then $\Sigma_i\, p_i^2$ will also be small, and the overall variance of the book will be very small, indicating a very low capital requirement.

While the simplified portfolio approach makes allowances for diversification and balanced books, it has several potential weaknesses arising from its simplifying assumptions. In particular, Sharpe's market model assumes that security returns are related only through a common relationship with a single "market" factor. This will not be true if a trading book is heavily weighted on a particular common factor, for example, on securities with common attributes such as energy stocks, financials or growth stocks. In such cases, equation (5) may underestimate variances and hence capital requirements. Similarly, equation (5) rests on the further simplifying assumptions that (i) all betas are unity and (ii) all stocks have the same residual variance. It is therefore an empirical question as to whether this provides a satisfactory

measure of the required amount of capital for a securities firm that specializes, say, in high beta or in low market capitalization/high residual risk stocks.

C. The Comprehensive Approach

An alternative method for setting capital requirements, currently applied by the SEC in the United States, is the comprehensive approach. Under this regime, firms are required to have capital equal to a specified proportion of the value of their long positions, plus a proportion of the value of qualifying shorts. Assuming the value of the long positions exceeds that of the shorts, the SEC demands 15 percent cover for all the long holdings and for all the short holdings whose value exceeds one quarter of the value of the long positions.

More generally, under the comprehensive approach the PRR, expressed as a percentage of the gross value of a portfolio that is net long, is:

$$PRR_c = \alpha[L + \text{Max}(S - \beta L, 0)] \tag{6}$$

where $L = \sum_i \text{Max}(p_i, 0)$, and $S = \sum_i \text{Max}(-p_i, 0)$ are respectively the total values of the long and short positions, expressed as a proportion of the total gross value of the portfolio.

For a portfolio of positions which is net short (i.e., one where $S > L$), the PRR is defined symmetrically, and hence the general expression for the PRR of any book, whether net long or net short, under the comprehensive approach is:

$$PRR_c = \alpha\{\text{Max}(L, S) + \text{Max}[\text{Min}(L, S) - \beta\ \text{Max}(L, S), 0]\} \tag{7}$$

The comprehensive approach has been the traditional method for specifying PRRs for many years, not only in the United States but in many other countries. The parameter requirements vary considerably, however. For example, α, the required percentage of position values, ranges from ten percent for liquid stocks in Japan, through fifteen percent in the United States and Australia, twenty percent in France and Italy, thirty percent for illiquid stocks in Holland, to no less than forty percent in Hong Kong. It also varies over time, and in the United States the requirement was relatively recently reduced from thirty to fifteen percent. Similarly, the percentage offset for qualifying short (for net long portfolios) or long (for net short portfolios) positions differs. Thus although the SEC permits an offset of one quarter (i.e., $\beta = 25$ percent), many countries impose requirements in respect of *all* positions, with no offsets, i.e., $\beta = 0$.

Quite clearly, the comprehensive approach is very ad hoc and takes virtually no account of portfolio considerations. It incorporates no allowances for diversification, and permits only a partial offset (when $\beta > 0$), or no offset at all (when $\beta = 0$) for balanced books. At best, it might be considered an appropriate system in a country/market in which trading books tend to be entirely long, as has hitherto been the case in many continental European

countries and for some U.S. broker dealers; and where books contain only a single security of roughly average risk, as might once have been the case for a few dedicated specialists. However, as a general rule to be applied across different markets and systems, where books can differ in their degree of diversification and their balance between long and short positions, it is grossly inadequate.

D. The Building-Block Approach

The building-block approach bases the capital requirement partly on the net, and partly on the gross, value of the book. If the parameters are a percentage X of the gross value of the book plus a percentage Y of the net value, this "$X + Y$" approach gives a capital requirement of:

$$PRR_b = X + Y\sum_i p_i \tag{8}$$

where p_i is defined as above, i.e., as the value of the holding in security i expressed as a proportion of the gross value of the book.

Once again, this approach is ad hoc. However, as noted by Levonian (1994), through basing capital requirements partly on the net value of the book, the method does recognize that, ceteris paribus, balanced books provide partial hedging and thus require less capital. In this respect, it constitutes a significant improvement over the comprehensive approach. Furthermore, we can interpret the parameter Y in equation (8) as relating to market risk. Thus for a fully diversified book, if Y were set to 8 percent, this would ensure sufficient capital to cover an 8 percent market fall (for net long books) or rise (for net short books). Relating this back to the simplified portfolio approach (equation (4)), this is equivalent to assuming the relevant time interval is one week, the required confidence interval is 95 percent, and the weekly standard deviation of market returns is 4 percent (versus the 2.6 percent assumed for the domestic equity market in the U.K.'s simplified portfolio approach).

The problem with the building-block approach, however, is that it gives no credit for diversification. From the perspective of portfolio theory, it can be justified only for fully diversified books, and if X is set to zero. For the kinds of trading books encountered in practice, an allowance needs to be made for their widely differing degrees of diversification (see Section IV), and this clearly cannot be achieved using a constant value for X.

The longest experience with the building-block approach was gained by the United Kingdom, over a period of several decades ending in 1988. The British required their single-capacity market makers, known before Big Bang as "jobbers," to have capital equal to $7\frac{1}{2}$ percent of their gross exposure plus $2\frac{1}{2}$ percent of their net exposure.[12] We refer to this as a "$7\frac{1}{2} + 2\frac{1}{2}$" building-block system. While the United Kingdom has since adopted the

[12] This applies to a set of holdings whose overall net value is long. The requirement was usually expressed as ten percent of the value of long positions (i.e., $7\frac{1}{2} + 2\frac{1}{2}$), plus five percent of the absolute value of the short positions (i.e., $7\frac{1}{2} - 2\frac{1}{2}$ percent of the negative holdings).

simplified portfolio approach, the building block approach, in the guise of a "4 + 8" and/or "2 + 8" system has now reemerged as the leading contender for international harmonization of capital requirements.

E. Attempts to Reach International Agreement on Capital Requirements

In 1988, the Basle Committee on Banking Supervision adopted the Basle Accord, which imposed an eight percent prudential capital requirement for banks. Though this accord drew on some ten years of experience in using a capital adequacy regime in the United Kingdom, the Basle Committee favored speedy development of a similar approach for securities firms, proposing the adoption of the building-block approach with $Y = 8$ percent. This would ensure a fundamental capital requirement that was consistent with the 8 percent requirement for banks, and would, allegedly, thereby create a "level playing field" (see Rose (1994)). Supplementary requirements could then be built up by adding incremental amounts to reflect other risk exposures incurred by securities firms. Crudely, the basic 8 percent requirement was intended to cover equity market exposure, while supplements would be added to reflect the extra risks of running a potentially undiversified two-way (long plus short) book. In early 1992 the European Commission (EC) also came out in favor of the building-block approach, publishing an amended proposal for a capital adequacy directive, the final version of which was published a year later (see European Commission (1993)). The background to the debate is discussed in Dale (1991), Waters (1992), Lee (1992), and Steil (1994).

International securities regulators, on the other hand, under the banner of the International Organization of Securities Commissions (IOSCO) were initially heavily influenced by the United States in favoring the "comprehensive" approach. In a series of discussions with the Basle Committee, however, a number of compromises were reached, and unpublished documents (see Basle and IOSCO (1992)) indicate that IOSCO was prepared, at least in principle, to accept the building-block approach as the basis for international agreement.

Initially, the building-block parameters proposed were $X = 4$ percent and $Y = 8$ percent (hereafter "4 + 8"). Many regulators, however, argued that "2 + 8" would be a more appropriate requirement for firms holding large, diversified portfolios, although it was agreed that individual securities (and concentrated portfolios) should continue to carry a 4 percent requirement. In early autumn 1992, the EC finally agreed its CAD, and this was based on the "2 + 8" model. Both the Basle Committee and the EC hoped that this would serve as the model for subsequent international agreement.

This was not to be, however, due to a disagreement over parameter values. At IOSCO's annual conference in October 1992, the "2 + 8" building-block proposal encountered implacable opposition from Richard Breeden, wearing his twin hats as Chairman of both the SEC and IOSCO's technical committee. Breeden was reportedly holding out for "4 + 8," and described "2 + 8" as

"imprudent in the extreme," arguing that it would be better if agreement was "never reached" than to accept this proposal (see Corrigan and Peston (1992) and Peston and Corrigan (1992)).

The debate which led to this impasse was highly political, involving extensive lobbying, intricate negotiations, and some horse-trading.[13] A major factor was the distinction between banks and securities firms, and the desire to create a level playing field across countries and between banks and securities houses.[14] There was also a very real tension among the alternative procedures for determining capital adequacy. This may have stemmed partly from pride of authorship from particular negotiating countries, and partly from a failure to recognize that the structure of trading books can vary greatly between markets. But the issue that led to stalemate, as the above quotation from Richard Breeden reveals, was the tension arising from different views about what level of capital would ensure "prudence."

A major casualty of this debate was the simplified portfolio approach that was rejected by EC, Basle Committee and IOSCO representatives during successive rounds of the international negotiations. This is lamentable, since theory suggests that a portfolio-based methodology should provide the best guide to position risk, and there was some evidence to support this (see Schaefer (1990)). The stated reasons for rejecting the portfolio approach were that international regulators felt it was i) too complex and ii) generated capital requirements that were much lower than those demanded by alternative methods. The debate between the proponents of the comprehensive approach and supporters of the building-block approach followed similar lines, although the arguments here were about capital requirements, rather than complexity. In particular, some regulators felt that building-block requirements were unacceptably low (see Waters (1992)) and that the comprehensive approach did not suffer from this drawback. And as we have seen, the ultimate failure to reach agreement was based on the alleged imprudence of the "2 + 8" building-block approach, which is now in the process of being implemented throughout the European Union (see Bank of England (1995) and Securities and Futures Authority (1995)).

The argument that the simplified portfolio approach is too complex is hard to sustain. In common with the other procedures, this approach requires (i) just two parameters and (ii) information on holdings in the form of the

[13] For example, Lee (1992) reports that "The capital adequacy directive is politically inspired. It is the Bundesbank's price for supporting the investment services directive (ISD), with which the British are keen to press ahead... The ISD will establish a passport for any firm authorized by a competent national regulator to offer investment services in any EC country." Lee argues that the CAD "is not really about prudent regulation, or level playing fields. It boils down to vested interests trying to skew the regulations to obtain a competitive advantage."

[14] A central issue here is whether there is any rationale for advocating a level playing field between banks and securities firms in terms of capital requirements. Schaefer (1992) points out that the socially optimal capital requirement for a particular type of institution will depend on the systemic costs imposed on society by its failure. A priori, it seems unlikely that the cost of collapse for securities firms is as great as the social costs of bank failures. If so, there is no case for a level playing field.

percentage of portfolio value represented by each constituent. To estimate capital requirements, the identity of each constituent need not be ascertained. Furthermore, the formula is extremely simple (see equation (4)), although some regulators argued that it did not meet the test of being a "pencil and paper" system. Squares and square roots are, according to this view, too complex to form part of the computational procedure. We do not find this assertion credible.[15]

F. Choice of Approach versus Choice of Parameters

The nature of the debate about which approach leads to the highest or lowest capital requirements is even more unsatisfactory. The three alternatives are simply computational procedures that involve different adjustments for "netting off" short from long positions and/or for taking account of diversification. It is the choice of *parameter values*, not the choice of method, that determines whether capital requirements are on average "high" or "low." The SEC's 15 percent capital requirement for an all-long book under the comprehensive system, for example, is obviously higher than the 12 percent required under the "4 + 8" building-block approach; but this could be reversed, simply by changing the parameter values. Similarly, if the net book is small in value compared to the gross book, the SEC's requirement exceeds the "4 + 8" building-block requirement by an even larger margin. But this does not mean that the comprehensive approach per se is inherently more prudent. It simply reflects the choice of parameters, and the failure of the comprehensive approach (given this choice of parameters) to make an adequate "netting off" adjustment.

The regulators' debate has, in fact, focused on the *joint* impact of the choices of method and parameter values proposed by the adherents of each approach. In this article we unravel these two issues. First, using a large sample of equity trading books for U.K.-based securities firms, we compute the PRRs demanded under the current U.S., the "4 + 8" building-block, and the existing U.K. requirements: on average, the U.S. system requires the most capital, and the U.K. system the least. We then estimate the parameter values that would generate the same average capital requirement under each of the three approaches, but with differing requirements for each individual book. We find that for a given average level of capital, the simplified portfolio approach allocates capital most efficiently; and the comprehensive approach is least efficient. From the perspective of economic efficiency and even

[15] Even if some firms found the simplified portfolio approach too complex, one could follow the approach adopted in the U.K. Financial Services Act and SIB/SFA rulebooks. Here, firms wishing to avoid complexity can use Method 1 (the "simple man approach"), and calculate PRRs as a percentage of the gross value of their positions. The cost of this simplicity, however, is higher capital requirements, since if they wish to obtain any credit for running well diversified and/or balanced books, they must adopt Method 2, which encapsulates the simplified Sharpe approach. The U.K. experience demonstrates that firms are quite ready to calculate square roots if this serves to lower their capital requirements.

investor protection, the portfolio approach dominates both the SEC's current method and also the building-block framework favored by the Basle Committee and the EC.

III. Sample Description

Our primary data consists of the precise composition of 58 U.K. equity trading books, collected from securities firms acting as market makers within the United Kingdom, as at various dates between December 1986 and September 1988. The books were made available to us on an exclusive basis by members of the Securities and Futures Authority (SFA), the U.K. self-regulatory authority responsible for firms dealing in securities and commodities. They cover sixteen market-making firms, a majority of those who currently deal in the U.K. equity market, both by number of firms and volume of business. There are between one and six trading books per firm, and they represent the overnight U.K. equity exposure[16] of the firms on thirty different dates. Some of the books are drawn from the period in which the United Kingdom followed the building-block approach for setting capital requirements, while others were held after the simplified portfolio approach was introduced as part of the 1988 Financial Services Act.

The 58 individual books range in gross value from £200 million to under £1 million. U.K. market makers are free to run a bullish (long), balanced (market-neutral), or bearish (short) book, depending on market conditions and their business judgement (see Hansch and Neuberger (1995)). Our sample includes all three types of exposure, with net values (the value of long minus the absolute value of short positions) ranging from a £104 million long position down to a £21 million short position. The ratio of long to short exposure varies from a very bullish 97:3 to a bearish 36:64, while several books are so finely balanced that they have an average net value equal to between zero and four percent of their gross value. Net exposure can also change rapidly, an observation also made by Hansch, Naik, and Viswanathan (1995), and for one firm it flips from -30 to $+48$ percent of gross value within a few weeks.

While net exposure can change quickly, other attributes change little over time. This is because they reflect the nature of the firm's business, such as the number of securities in which they make markets, and whether they specialize by sizes/types of stocks. Our sample represents a good cross-section of different types of firm. For example, the number of positions held varies across our sample books from 1426 to only 18 shares (of the 2120 U.K. shares quoted). Similarly, the books are invested in companies whose market

[16] Positions in overseas equities are ignored. We also omit positions in options and futures, partly because this information was unavailable for some firms, but mainly because our focus is on the underlying equity positions. In a few cases, where equity holdings are specifically identified as hedge positions (e.g., where the securities firm is also a market maker in options), these, too, are omitted.

capitalization has an exposure-weighted average ranging from over £5 billion for one firm to less than a fiftieth of this for another. One sample firm's positions were entirely in the most liquid "alpha" category of U.K. stocks, while another's were almost entirely in the most illiquid "gamma" category. Finally, some firms had as much as half their books in a single industry sector, while it was also common for one or more sectors to be virtually or totally absent.

Quite apart from these size, marketability, and sector tilts, our data also confirm that firms take on considerable additional risk through imbalances in their holdings. One position or a small number of large positions can dominate the capital invested in the book, despite the very substantial number of smaller positions that are held (see Dimson and Marsh (1995)). Our 58 books thus vary greatly both in the extent and direction of their net exposure, and in their number of holdings and degree of concentration. Since our sample is representative of the U.K. market, this serves to emphasize that PRRs need to reflect the extent to which individual books are balanced and/or diversified. Our study is thus based on a set of books that are sufficiently diverse to conduct a robust analysis of the efficacy of alternative methods.

IV. Research Design

For each of the equity trading books we calculate their capital requirements under the simplified portfolio, the comprehensive, and the building-block approaches, using equations (5), (7), and (8) respectively. Since these PRRs have the objective of covering unanticipated changes in the value of the books, we compare them with the volatilities of the returns on the books. The volatility of each book is estimated by computing its monthly standard deviation of returns over a sixty-month interval prior to the date of the book. Volatilities are estimated from a simulated back-history of the returns on the book, computed on the assumption that the long and the short side of the book are held in the same fixed ratio as on the observation date, and that the individual securities are similarly held in the same constant proportions within both the long and the short sides of the book.[17]

To examine the extent to which these volatilities are related to the PRRs for each book, we use ordinary least squares. The PRRs defined in equations (5), (7), and (8), however, are all expressed as a percentage of the gross value of the books, while the volatility estimates are based on the returns on the net books. For consistency, and to control for heteroskedasticity, we therefore

[17] Our data source is the London Business School's share price database, the LSPD, as described in Dimson and Marsh (1983). Individual securities with less than 12 months returns history are excluded from this volatility calculation. For consistency, these securities are also excluded when calculating capital requirements using equations (5), (7), and (8).

scale the volatilities so that they are also expressed as a percentage of the books' gross values.[18] The regression is therefore:

$$\hat{\sigma}_j = \gamma_0 + \gamma_1 PRR_{jm} \tag{9}$$

where PRR_{jm} signifies the PRR for book j computed using methodology m, and $\hat{\sigma}_j$ is the scaled volatility estimate for book j, obtained by multiplying the volatility estimated from returns on the net book by the factor $\Sigma_i p_{ij}$, where p_{ij} is the value of holding i in book j expressed as a proportion of the total gross value of book j.

In estimating equation (9), we are concerned with the strength of the relationship between volatilities and the PRRs calculated under the alternative regulatory frameworks. Our focus is thus on the t-value of the slope coefficient, γ_1, and on the R^2. Ultimately, however, our concern is with how close the different PRRs are to the optimal capital requirements for each book. We assume here that the optimal capital requirement for a book will minimize the sum of the expected costs to both securities firms and to society, and that it is some multiple, λ, of the book's volatility. If PRRs are set above this optimal level (i.e., if $PRR_{jm} > \lambda\sigma_j$), then although this reduces the risk and hence expected costs of default, this is more than outweighed by the extra costs imposed on securities firms from forcing them to hold excess capital. Similarly, if PRRs are set below their optimal level, then although the costs to securities firms are lowered, this is more than offset by the additional expected costs of default. An ideal system for setting PRRs would thus be one where the resultant PRRs were as close as possible to $\lambda\sigma_j$ for each book.

The criterion which we use to judge the performance of the three methodologies is thus the mean squared error (MSE) of the difference between our estimate of the optimal capital requirement, $\lambda\hat{\sigma}$, and the actual capital requirement, PRR_{jm}. Our definition of the MSE is:

$$MSE_m = \sum_j \left(\lambda\hat{\sigma}_j - PRR_{jm}\right)^2 / n \tag{10}$$

where MSE_m is the MSE for method m, and n is the number of books. The strength of the MSE criterion is that it recognizes that both under- and overestimates of capital requirements carry a cost, and thus provides a direct proxy for the "system cost" of each methodology. With more information on the nature and relative magnitude of the costs of under- or overestimates, it might be possible to improve on this measure. However, in the absence of such information, we have chosen to work with the MSE criterion and its implicit assumption of a quadratic loss function.

[18] Expressing the PRRs as a proportion of the gross value of the book not only seems the most obvious metric, but also has an economic interpretation. It links capital costs to the value of business done, and hence to the spread charged by the market maker. In addition, when PRRs are expressed as a percentage of the gross book, the figures can readily be compared with capital ratios for other assets.

In computing MSEs, we initially assume that $\lambda = 1$ in equation (10), i.e., that the optimal PRR is equal to the monthly standard deviation of returns. Since the latter is equal to twice the weekly standard deviation, this is equivalent to assuming that the optimal PRR should be set so as to provide for securities firms being at risk for one week, coupled with a confidence interval of 95 percent. These are the assumptions behind the choice of parameters in the U.K.'s simplified portfolio approach (see Section II.*B* and equation (4)).

In our initial comparison of the three methodologies, we estimate equation (9) and compute MSEs from equation (10) based on PRRs calculated using the parameter values currently in use or proposed for each of the systems. The initial parameter values used are the current SEC values for the comprehensive approach (i.e., $\alpha = 15$ percent and $\beta = 25$ percent); the "4 + 8" parameters for the building-block approach (i.e., $X = 4$ percent and $Y = 8$ percent); and the current U.K. parameters of $\sigma_m^2 = 6.75$ and $\sigma_\varepsilon^2 = 21.5$ for the simplified portfolio approach.

Our analysis reveals that these parameter values result in very different average PRRs for the three alternative procedures. Thus, while the simplified portfolio approach appears to be the superior methodology, it generates the lowest PRRs and might therefore be viewed as imprudent. Its lower requirements, however, simply follow from the choice of parameters. To separate parameter choice from judgements about methodologies, we therefore repeat our analysis, abstracting for differences in the mean requirements. The parameter values used for both the simplified portfolio and comprehensive approaches are thus scaled to ensure that both systems generate the same mean PRR for the 58 trading books as the "4 + 8" building-block approach. We standardize on the latter since it represents the compromise level that even the SEC may have been prepared to accept as "prudent" (see Corrigan and Peston (1992) and Peston and Corrigan (1992)). For consistency, we also scale our estimates of the optimal capital requirements by increasing the value of λ, so that the mean value of $\lambda\hat{\sigma}$ also corresponds to this same mean capital requirement which, arguably, is close to the level that international regulators (at least implicitly) regard as optimal.[19] We then recalculate PRRs using these modified parameters, reestimate equation (9), and recompute the MSEs using equation (10).

Even after adjusting for differences in the mean PRR, the relative performance of each procedure could still reflect a less-than-ideal choice of parame-

[19] As noted above, international regulators have so far failed to reach agreement. Many regulators appear to regard the European Union's "2 + 8" system as optimal, while others, particularly the SEC, have not been prepared to move below the earlier Basle/IOSCO proposal of "4 + 8", viewing even this as barely prudent. Although our analysis in Section V below is standardized on the mean capital requirements generated by the $X = 4$, $Y = 8$ parameters, we also examine whether alternative ratios of X:Y such as 2:8 would generate lower MSEs (see Section VI).

ters, rather than a deficiency in the underlying method. To investigate this, Section VI examines how much better each method performs when the requisite parameters are set to optimal (in-sample) values.

V. Results

A. Comparison of the Three Approaches

Table I compares volatilities with PRRs for all three methods. The relationship is assessed by the cross-sectional regression (9) of volatilities on PRRs, using the parameter values specified by the U.S. SEC, the "4 + 8" building-block approach, and the U.K. Financial Services Act respectively. The first row of Table I shows that for the comprehensive approach, there is no evidence of any statistical link between the SEC's PRRs and portfolio volatility, and the adjusted R^2 is actually negative. This is hardly surprising since the comprehensive approach takes no account of diversification, and the SEC's parameters provide only a very limited offset ($\beta = 25$ percent) for balanced books. The SEC comes close to specifying capital requirements that are a fixed percentage of the gross value of the book.

The second row of Table I shows the corresponding results for the EC building-block approach, using the "4 + 8" parameters. This indicates a distinct improvement over the comprehensive approach, and there is a demonstrable link between building-block PRRs and volatilities with a t-value of 9.7 for the slope coefficient and an adjusted R^2 of 62.3 percent. Again, this is consistent with expectations. Although the building-block approach makes no allowance for diversification, it does link PRRs to the portfolio's net value, thereby recognizing that balanced books provide partial hedging and thus require less capital.

The U.K.'s portfolio approach performs even better, with a t-value of 16.9 for the slope coefficient and an adjusted R^2 of 83.3 percent. These results are based on parameters currently in use in the United Kingdom.[20] We noted in Section II.*B* that these parameters were chosen with a view to generating PRRs that were equal to twice the weekly standard deviation of returns. Since the latter is roughly equivalent to the monthly standard deviation, the slope coefficient in Table I should not differ markedly from a value of 1.0. Despite all of the approximations implicit in the simplified portfolio approach, the slope coefficient of 0.91 is not significantly different from the expected value of 1.0. On this evidence, the simplified portfolio approach appears better than the building-block approach, and far superior to the SEC's comprehensive approach, at capturing the volatility of actual books.

[20] These parameters exclude any liquidity adjustment since the concern here is with the base PRR designed to cover the volatility of the book. The actual U.K. capital requirement would be identical to the PRR computed here only for books composed solely of the most liquid category of securities (see Section II.*B* and footnote 11); for other books, the actual requirement would be larger.

Table I

Regression of Volatility on Capital Requirements Based on Current Parameters

In each row of the table, σ_j, the ex post volatility (expressed as a percentage of the gross book), is regressed on PRR_{jm}, the position risk requirement (also expressed as a percentage of the gross book) for book j computed using method m. The regression equation is $\hat{\sigma}_j = \gamma_0 + \gamma_1 PRR_{jm}$. In the first row, PRRs are based on the comprehensive approach (equation (5)) using the SEC parameters $\alpha = 15$ and $\beta = 25$ percent. In the second row, PRRs are based on the building-block approach (equation (7)) using the parameters $X = 4$ and $Y = 8$ percent. In the third row, PRRs are based on the portfolio approach (equation (8)) using the U.K. parameters $\sigma_m^2 = 6.75$ and $\sigma_\varepsilon^2 = 21.5$. To check whether the basic PRRs reflect the volatilities of the trading books, none of the PRRs incorporate liquidity adjustments and they therefore represent the requirements only for books containing the most liquid securities.

			Mean PRR as percentage of		Regression of Volatility on PRR			
Approach	Parameter Values		Net	Gross	γ_0(t-value)	γ_1(t-value)	Adj.R^2	MSE
Comprehensive	$\alpha = 15$	$\beta = 25$	72.2	12.6	−0.65 (0.2)	0.31 (0.9)	−0.3	90.03
Building-block	$X = 4$	$Y = 8$	30.5	7.2	−0.48 (1.2)	0.51 (9.7)	62.3	17.10
Portfolio	$\sigma_m^2 = 6.75$	$\sigma_\varepsilon^2 = 21.5$	17.7	3.5	0.05 (0.3)	0.91 (16.9)	83.3	0.33

The final column of Table I shows the MSEs for the three alternative methods. The simplified portfolio approach, with a MSE of only 0.33 appears greatly superior to the building-block approach, with a MSE of 17.1, and the comprehensive approach, with a MSE of 90. This comparison, however, is potentially unfair to the comprehensive and building-block approaches, since it is predicated on the assumption that the optimal level of capital requirements, $\lambda\sigma$, is given by $\lambda = 1$. As noted above, this is the assumption that underlies the choice of parameters in the U.K.'s simplified portfolio approach.

Table I shows that the U.K.'s simplified portfolio approach generates a lower mean PRR than either the building-block or, even more obviously, the SEC's comprehensive approach. The mean PRR across all books in the sample varies from 12.6 percent of gross value (72.2 percent of net value) for the SEC's comprehensive approach, through 7.2 percent of gross value (30.5 percent of net value) for the "4 + 8" building-block approach, to as low as 3.5 percent of gross value (17.7 percent of net value) for the U.K.'s portfolio approach.[21] Arguably, these differences reflect each authority's differing view of the optimal level of capital requirements. If so, advocates of the "4 + 8" system, and a fortiori those supporting the comprehensive approach with the SEC's current choice of parameters, must implicitly be assuming that the optimal level of capital is given by values of λ that are much greater than unity.[22] The MSEs in Table I, however, are all computed on the assumption that $\lambda = 1$, so it is not surprising that the simplified portfolio approach generates the lowest MSE. The MSEs for the other two approaches will inevitably be much larger because they incorporate a large bias term arising from the difference between the mean PRRs (which assume $\lambda > 1$), and the mean assumed "optimal" capital requirement (based on $\lambda = 1$). We need to abstract from these differences before we can make valid comparisons between methods.

B. Abstracting for Differences in Mean PRRs

To abstract from these differences in mean PRRs we need to rescale the parameter values to ensure that all three approaches require the same mean level of capital. One possibility would be to standardize on the U.K. authorities' assumption that $\lambda = 1$, and scale down the parameter values for the building-block and comprehensive approaches. We have already noted, how-

[21] The figures here are for the U.K. approach excluding liquidity adjustments. When liquidity adjustments are added for each of the 58 trading books, the mean PRR rises to 5.1 percent of gross value (25.8 percent of net value). It is worth noting, however, that other approaches also incorporate liquidity adjustments. For example, the comprehensive approach as implemented by the SEC demands higher capital requirements (i.e., it prescribes a higher level of α) for certain categories of less liquid equities.

[22] For our sample of 58 trading books, the mean PRR for the simplified portfolio approach is equal to 1.09 times the mean monthly standard deviation of returns, while the corresponding figures for the "4 + 8" building-block and the SEC's comprehensive approach were 2.24 and 3.93, respectively. Arguably, therefore, advocates of the "4 + 8" building-block and the SEC's current system are implicitly assuming that the optimal level of capital is given by setting λ equal to 2.24 and 3.93 respectively, rather than to the value of unity assumed in Table I.

ever, that international regulators have rejected the portfolio approach as imprudent, because it generates requirements that they deem too low. But even if they are correct about the prudential level of capital, this does not justify rejecting the portfolio approach. The mean PRR for the portfolio approach could be made greater simply by increasing σ_m^2 and σ_ε^2, or by requiring cover of more than two standard deviations of weekly returns.

Equally, however, it is not clear why the mean PRR for the United Kingdom is viewed as being too low. International regulators must implicitly be asserting that one week is too short, and/or that the variance estimates used are too low, and/or that a 95 percent confidence interval is insufficiently prudent. Furthermore, those who assert that the "4 + 8" building-block approach represents the minimal prudential requirement are arguing for a mean PRR of more than twice (i.e., 7.2/3.5 = 2.1 times; see Table I) the level required in the United Kingdom. This implies either that securities firms require 2.1 weeks to trade out of their positions, or that market and residual variances should be set at 2.1^2, or more than four times their historically estimated levels, or that the confidence level should exceed 99.99 percent. It is far from obvious that this is correct, particularly since complex considerations are involved, such as the time required to trade out of positions, the likely regulatory delay, and the differential costs of requiring too much or too little capital.

Our concern, however, is not to assess which authority is "correct" in its choice of the level of optimal capital requirements, but instead to take the latter as given, and to determine which methodology then results in the most efficient use of capital. We therefore assume that the average level of capital required is equivalent to the mean PRR generated by the "4 + 8" building-block approach, i.e., the compromise level that even the SEC might have accepted as prudent (see Corrigan and Peston (1992) and Peston and Corrigan (1992)). We therefore scale the parameter values for the other two approaches to ensure that the overall amount of capital required for our entire sample is the same for all three methodologies, namely, 7.2 percent of the gross value of the books (see Table I). This implies parameters of $\alpha = 8.5$ percent and $\beta = 25$ percent for the comprehensive approach, and $\sigma_m^2 = 13.9$ and $\sigma_\varepsilon^2 = 44.3$ for the simplified portfolio approach.[23] For consistency, we also scale up our estimates of the optimal level of capital requirements by multiplying the dependent variable in equation (9) by a factor of 2.24 (see footnote 22), and by substituting $\lambda = 2.24$ into our calculations of MSEs using equation (10).

Table II shows the rescaled parameter values, while the column headed Mean PRR shows that the amount of capital required for our entire sample is now identical across all methods, namely 7.2 percent, on average, of the gross

[23] We scale the market and mean residual variance parameters by the same multiplier, since this is equivalent to changing (i) the length of time required to trade out of the positions in a trading book, and/or (ii) the regulatory authority's preferred confidence limit for the PRR, and/or (iii) all security variance estimates by a constant factor. It is also equivalent to an across-the-board adjustment to the estimated liquidity of the securities within the book (see Section II.*B* and footnote 11).

Table II

Regression of Volatility on Capital Requirements Based on Rescaled Parameters

In each row of the table, $\hat{\sigma}_j$, the ex post volatility (expressed as a percentage of the gross book) is regressed on PRR_{jm}, the position risk requirement (also expressed as a percentage of the gross book), for each book j computed using method m. The regression equation is $\hat{\sigma}_j = \gamma_0 + \gamma_1 PRR_{jm}$. In the first row, PRRs are based on the comprehensive approach (equation (5)) using the rescaled parameters $\alpha = 8.5$ and $\beta = 25$ percent. In the second row, PRRs are based on the building-block approach (equation (7)) using the parameters $X = 4$ and $Y = 8$ percent, as in Table I. In the third row, PRRs are based on the portfolio approach (equation (8)) using the rescaled parameters $\sigma_m^2 = 13.9$ and $\sigma_\varepsilon^2 = 44.3$. The rescaled parameters ensure that all three methods have the same average PRR as a proportion of the gross book. As in Table I, none of the PRRs incorporate liquidity adjustments.

			Mean PRR as percentage of		Regression of Volatility on PRR			
Approach	Parameter Values		Net	Gross	γ_0(t-value)	γ_1(t-value)	Adj.R^2	MSE
Comprehensive	$\alpha = 8.5$	$\beta = 25$	41.0	7.2	−1.45 (0.2)	1.20 (0.9)	−0.3	7.22
Building-block	$X = 4$	$Y = 8$	30.5	7.2	−1.08 (1.2)	1.15 (9.7)	62.3	2.79
Portfolio	$\sigma_m^2 = 13.9$	$\sigma_\varepsilon^2 = 44.3$	36.5	7.2	0.11 (0.3)	0.98 (16.9)	83.3	1.20

value of the books. By standardizing overall capital requirements, we have thus ensured that the portfolio approach can no longer be deemed imprudent. However, a simple rescaling of parameters can have no impact on the strength of the relationship between the volatilities and PRRs of the books. This is confirmed by a comparison of the regression results in Tables I and II, which shows that although the coefficient estimates have now changed in line with the rescaling of the variables, the R^2s and t-values all (by definition) remain unchanged.

Table II thus shows that the simplified portfolio approach continues to exhibit the highest R^2 and the highest t-value for the slope coefficient. In addition, however, the final column of the table shows the MSEs for each method. We can now make straightforward comparisons, since we have eliminated the bias terms that were present in Table I. The best performance is given by the simplified portfolio approach, with a MSE of 1.2, followed by the building-block method with a MSE of 2.8, and then the comprehensive approach with a MSE of 7.2. For a given level of capital, the simplified portfolio approach is by far the superior method, allocating capital more efficiently and with a lower system cost than the other two methods.[24] In contrast, the comprehensive approach is the least efficient method.

VI. The Choice of Parameter Values

We have so far evaluated the three approaches using the actual (or rescaled) parameters employed by the major protagonists for each system. Conceivably, this may have done a disservice to one or more approaches, since an alternative structure (rather than just a rescaling) of parameters might generate a closer linkage between PRRs and volatilities.[25] To investigate this, we reestimate the parameters for each approach so as to minimize the MSE computed using equation (10).[26] The results need to be treated with care since our sample could be unrepresentative of its universe. Nevertheless, *if* markedly better performing parameters can be found for the comprehensive and building-block approaches, our unfavorable comparison with the portfolio approach may be overstated.

[24] We are assuming that the MSE provides a reasonable proxy for system costs. As noted above, the MSE implicitly assumes a quadratic loss function, although we have very little information on whether this is appropriate. However, we can think of no functional form for the loss function which would alter the *ranking* of our results, or our conclusion that the portfolio approach is the superior methodology.

[25] The existing parameters are anyway not set in stone. For example, the debate between the EC, the Basle Group, and IOSCO centered around the merits of the "2 + 8" building-block system, and the PRRs given by these parameters would inevitably perform differently from the "4 + 8" regime. Similarly, the U.K.'s Securities and Investments Board has commissioned research on how best to update the parameters of its simplified portfolio approach (see Dimson and Marsh (1990)).

[26] We used maximum likelihood estimation throughout, namely ordinary least squares for computing the optimal in-sample parameters for the building-block approach, and search methods for the other two approaches.

Table III presents the results. Each row shows the parameter values that minimize the MSE, together with the corresponding regression results from equation (9) and MSE estimates from equation (10). To ensure consistency with the results in Table II, parameter values, volatilities, and the assumed optimal level of capital have once again been rescaled so that all PRRs continue to have a mean value of 7.2 percent of the gross value of the book.

A comparison of Tables II and III shows that while using optimal in-sample parameters lowers the MSEs for all three methods, the reduction is greatest (namely, one half) for the comprehensive approach. The improvement in the regression results for the comprehensive approach is even more marked, with the R^2 increasing from approximately zero to 63.4 percent, and the t-value of the slope coefficient, γ_1, rising from 0.9 to 10.0. This markedly better performance is obtained by moving from parameter values of $\alpha = 8.6$ and $\beta = 25$ percent (Table II) to $\alpha = 10.3$ percent and $\beta = 90$ percent (Table III). The key parameter here is β, the percentage offset in equation (7), and closer analysis shows that as β is increased to 100 percent (or more), the MSE effectively remains constant at 3.61.

The comprehensive approach is thus at its most effective when maximum offsets are permitted. Thus although comprehensive approach PRRs take no account of diversification, when $\beta \approx 100$ percent, PRRs range from $\alpha/2$ percent for perfectly balanced books up to α percent for all long (or short) books and are thus correlated with a book's market risk. But with zero offsets, namely $\beta = 0$, this correlation disappears, since PRRs are then related neither to a book's diversification (residual risk) nor its degree of balance (market risk). The comprehensive approach is therefore wholly ineffective when expressed in its "purest," fully *comprehensive* form, with no offsets. It works best when $\beta = 100$ percent, in which case the comprehensive approach collapses to the building-block approach, with $X = Y = \alpha/2$. However, it is unlikely that the SEC would recognize this special case of the building-block approach (equation (8)) as being a variant of the comprehensive approach (equation (7)).

Note, however, that even with data-mining/maximum offsets, the comprehensive approach MSE of 3.61 (in Table III) is still inferior to both the "4 + 8" building-block and the U.K. simplified portfolio approaches *without* data-mining, whose MSEs are 2.79 and 1.20 respectively (see Table II above). The reason for this is that, with the comprehensive approach of equation (7), even when $\beta \geq 100$ percent, perfectly balanced books still face a charge for their long positions equal to half the book's gross value. Although β is referred to as an "offset" parameter, the offset is against the book's gross value, not of longs against shorts. In contrast, both the building-block and portfolio approach allow for the fact that in balanced books, the market risk of the long and short positions is offsetting.

The second row of Table III shows that the optimal in-sample parameters for the building-block approach are 3.5 percent of the book's gross value plus

Table III

Optimal In-Sample Parameters for Regression of Volatility on Capital Requirements

In each row of the table, $\hat{\sigma}_j$, the ex post volatility (expressed as a percentage of the gross book) is regressed on PRR_{jm}, the position risk requirement (also expressed as a percentage of the gross book), for each book j computed using method m. The regression equation is $\hat{\sigma}_j = \gamma_0 + \gamma_1 PRR_{jm}$. In the first row, PRRs are based on the comprehensive approach (equation (5)). In the second row, PRRs are based on the building-block approach (equation (7)). In the third row, PRRs are based on the portfolio approach (equation (8)). For each method, parameter values are chosen to minimize the in-sample MSE computed using equation (10) subject to the constraint that the in-sample mean PRR is equal to 7.2 percent of the value of the gross book. Note that, as in Tables I and II, none of the PRRs incorporate liquidity adjustments.

Approach	Parameter Values		Mean PRR as percentage of		Regression of Volatility on PRR			
			Net	Gross	γ_0(t-value)	γ_1(t-value)	Adj.R^2	MSE
Comprehensive	$\alpha = 10.3$	$\beta = 90$	34.3	7.2	−6.04 (4.5)	1.84 (10.0)	63.4	3.61
Building-block	$X = 3.5$	$Y = 9.2$	30.5	7.2	0.00 (0.0)	1.00 (9.7)	62.3	2.71
Portfolio	$\sigma_m^2 = 20.0$	$\sigma_\varepsilon^2 = 30.5$	33.9	7.2	0.29 (0.8)	0.96 (19.3)	86.7	0.96

9.2 percent of its net value. The use of these optimal parameters in preference to "4 + 8", however, leads to only a small (3 percent) reduction in the MSE from 2.79 (Table II) to 2.71 (Table III), while the R^2 and the t-value of the slope coefficient remain unchanged. (Because the building-block PRR is simply a linear function of each book's net to gross value, the regression results reported in Table II have already maximized the R^2 and t-value so that no further improvement is possible.) These optimal in-sample parameters may help shed some light on the debate between regulators over the relative merits of a "4 + 8" versus an "2 + 8" building-block system. Clearly, the relative efficiency of different parameter combinations depends on the ratio X:Y. Our original results (in Table II) were for the "4 + 8" system, whereas the ratio built into the EC directive is 2:8. The latter "2 + 8" system has been criticized by the SEC for generating capital requirements that are imprudently low. This criticism misses the point, however, since regulators should first decide what *ratio* of X:Y maximizes efficiency, and then scale both X and Y to ensure that the mean PRR meets prudential requirements. Interestingly, for our sample of UK books with $X = 3.5$ and $Y = 9.2$, the in-sample optimal ratio of X:Y is actually 3:8, which lies between the disputed values of 4:8 and 2:8.[27] The evidence from Tables II and III suggests that adopting a 3:8 rather than a 4:8 (or by implication, a 2:8) ratio is likely to lead to only modest improvements in the MSE, however, and the optimal ratio of 3:8 is, in any case, generated by data-mining.

The third row of Table III shows that the performance of the simplified portfolio approach can also be improved by using optimal in-sample parameters. Furthermore, the 20 percent reduction in the MSE from 1.20 (in Table II) to 0.96 (in Table III) is much greater than was the case for the building-block approach. There is also an equivalent increase in the adjusted R^2 (from 83.3 to 86.7) and in the t-value of γ_1 (from 16.9 to 19.3). The optimal in-sample parameters giving rise to this improvement are $\sigma_m^2 = 20.0$ and $\sigma_\varepsilon^2 = 30.5$. By construction, these generate the same mean PRR as the parameters in Table II, i.e., $\sigma_m^2 = 13.9$ and $\sigma_\varepsilon^2 = 44.3$. They generate a lower MSE only because they assume a higher ratio of market variance to mean residual variance. In Table III, $\sigma_m^2/\sigma_\varepsilon^2$ is 0.66, compared with 0.31 based on the parameters selected by the U.K. authorities and used in Tables I and II.

The question that arises is whether the lower MSE achieved using optimal in-sample parameters is simply the result of ex post data-mining, or whether

[27] This tentative result must not be generalized to different market settings or countries, where the type and mix of books is significantly different. For example, in countries where securities firms' trading books are all long (as tends to be the case in many European countries other than the United Kingdom), books will tend to have higher market risk than in the UK, and this in turn implies a higher mean capital requirement. At the same time, there would be no relationship between trading book volatilities and building-block PRRs, whatever the parameter values chosen. Under these circumstances, the optimal building-block parameters would in fact be $Y = 0$, while X should be set equal to the mean desired PRR.

the ratio of $\sigma_m^2/\sigma_\varepsilon^2 = 0.31$ chosen for the United Kingdom was too low ex ante. The evidence tends to support the latter. The U.K. parameters were originally derived from data given in Quantec (1986), and in particular, σ_ε^2 was simply taken to be the equally weighted mean residual variance for all U.K. stocks as estimated by Quantec.[28] The use of this equally weighted figure gives rise to the $\sigma_m^2/\sigma_\varepsilon^2$ ratio of $6.75/21.5 = 0.31$ referred to above. In practice, the securities firms in our sample typically held positions that were intermediate in size distribution between equally and capitalization-weighted holdings. The optimal ex ante choice of σ_ε^2 is thus likely to lie somewhere between an equally and a capitalization-weighted mean residual variance.

To investigate the plausible range of values here, we estimated $\sigma_m^2/\sigma_\varepsilon^2$ for each of the trading books in our sample, using sixty months' returns data prior to the date of each book. In each case, σ_ε^2 was computed first as an equally weighted average, and second as a capitalization-weighted mean. The average value of $\sigma_m^2/\sigma_\varepsilon^2$ across all 58 trading books was 0.24 using an equally weighted mean (i.e., close to the figure of 0.31 obtained from Quantec), and 0.89 using a capitalization-weighted mean. Thus if, rather than using an equally weighted mean residual variance, the U.K. authorities had simply selected an ex ante value midway between the equally and capitalization-weighted mean values of 0.24 and 0.89, they would have obtained a value of 0.57. This would then have been much closer to the optimal in-sample value reported in Table III of $20.0/30.5 = 0.66$.

Our analysis of optimal in-sample parameter values provides confirming evidence on the inadequacy of the SEC's current regime, and also suggests several ways of further improving the portfolio approach. First, improvements could be achieved by varying σ_ε^2 to take account of the weighted-average market capitalization of a trading book's constituent securities. Second, σ_m^2 and σ_ε^2 need not be held constant over time but should regularly be updated, to ensure they are appropriate to the date in question. But, ultimately, the greatest improvement of all would be achieved by moving from the simplified to a full-blown portfolio approach, in which each book's variance is not approximated, but is instead estimated directly. To date, however, even the U.K. authorities have balked at this, believing it would be too complex for the less sophisticated securities firms.

[28] The Quantec estimates were obtained using sixty months of historical data from 1982 to 1986. The original Quantec estimate for the market variance was $\sigma_m^2 = 4.5$, but this was updated after the stock market crash of October 1987 to its current value of $\sigma_m^2 = 6.75$, equivalent to $\sigma_m = 18.7$ percent on an annualized basis. Most of the 58 trading books in our sample relate to 1988 and the postcrash period, although five books are taken from late 1986/early 1987. For the 1988 books, σ_m based on sixty months of historical data was 21 percent, while for the 1986/1987 books, the corresponding figure was 14 percent. This suggests that if a single value for σ_m is to be used across all 58 books, it should be around 20 percent, which is close to the U.K. authorities' choice of 18.7 percent. If the U.K. parameters reflect a suboptimal choice for the books/period in question, the problem is therefore more likely to lie in the choice of σ_ε^2, and hence in the ratio of $\sigma_m^2/\sigma_\varepsilon^2$, than in the estimate for σ_m^2.

VII. Conclusion

To be effective, any method for setting capital requirements should demand more capital when risk exposure is larger, and vice versa. In this study, we have examined the extent to which the PRRs generated by the comprehensive, the building-block, and the simplified portfolio approaches are related to the risks of trading books. Our tests are based on a sample of 58 books held by U.K.-based securities firms, where the books differ markedly in composition, balance, and diversification. Our results reveal that there is no correlation whatsoever between PRRs set by the SEC's comprehensive approach and the risks of the books. The building-block approach performs better, since it takes account of the reduction in market risk achieved when there are offsetting long and short positions, but because it ignores diversification, the correlation with total risk is still modest. In contrast, the U.K.'s simplified portfolio approach takes into account both a book's degree of balance and its diversification level; there is a high correlation between PRRs and the risks of the books.

Our results show unequivocally that the portfolio approach should be the preferred method for setting capital requirements. Yet international regulators have shown a marked preference for the building-block approach, while the SEC has so far displayed an extreme aversion to updating the U.S. rulebook.[29] This may partly reflect a failure to conduct research since hitherto, empirical evidence has featured little in this debate. Indeed, this study is the first to use data from actual books to address the issue. But undoubtedly, the preference for suboptimal methodologies also arises from faulty analysis and confusion over the real issues.

In particular, many international regulators have failed to differentiate between the level of capital implied by alternative regimes, and the efficiency with which capital is used under each regime. The U.K.'s simplified portfolio approach is therefore (spuriously) alleged to be imprudent, since it generates the lowest capital requirements, especially when compared to the comprehensive approach, which requires the highest level of capital.

Such comparisons are inappropriate for two reasons. First, they fail to recognize that these differential requirements stem from the choice of parameter values rather than the underlying method per se. As we have shown, the parameter values for the simplified portfolio approach can readily be increased to the point where it requires the same, or even more, capital than is currently demanded by other approaches. Second, such comparisons incor-

[29] The Washington cliché, "If it ain't broke, don't fix it," may explain some of this reluctance to accept change. However there are glimmerings that even the SEC's opposition may be softening. Commenting on the SEC's March 1995 proposal regarding charges for option positions, the Chairman of the SEC recently stated "This proposal is significant because it would incorporate, for the first time, modern portfolio theory into the net capital rule... Our goal is to revise completely the application of the net capital rule to OTC derivatives in a manner that both reflects modern financial theory and contemporary risk reducing techniques" (Levitt (1994)). Hopefully, the SEC's goal may be extended to embrace *all* of a securities firm's positions.

rectly assume that the most "prudent" method is automatically the best. But in reality there are costs involved if requirements are set too high (e.g., for securities firms and their clients, and in terms of impaired competition), as well as if they are too low. For this reason, our empirical tests focus not just on the correlation between PRRs and risk levels, but also on the MSE generated by the three methods.

Our results reveal that the simplified portfolio approach generates the lowest MSE; the building-block MSE was more than twice as large, while the comprehensive approach performed worst of all, with an MSE some six times larger. These MSEs provide a direct proxy for the relative system costs imposed by the three approaches, and they indicate that the portfolio approach uses capital most efficiently.

The portfolio approach's lower MSE also provides reassurance to practitioners concerned only with minimizing capital requirements, or to regulators concerned solely with prudence. For the former, it is easy to show that the portfolio approach parameter values can be scaled down to the point where the resultant PRRs generate an MSE that is, say, identical to that for the "4 + 8" building-block approach, but where the aggregate capital requirements are demonstrably lower. Similarly, for a regulator concerned only about prudence, parameter values could be increased to the point where, say, the MSE matched that of the building-block approach, but where the default risks are clearly lower. In this sense, the portfolio approach should be deemed the *most* prudent of the methodologies.

What will be the impact of the regulators' recent preference for the building-block approach? In fairness, this method incentivizes securities firms to control their net exposure to the equity market, and it may therefore reduce the systemic risk that might otherwise arise. On the other hand, it fails to reward firms for running well-diversified books. In contrast, the portfolio approach, which also offers a lower capital requirement for a well-diversified book, can be expected to reduce not only systemic risk but also the risk of failure by an individual securities firm.

Taking account of both the greater efficiency with which the portfolio approach allocates capital across books, and the favorable incentives it provides, we draw three conclusions. First, there is not a crumb of theoretical or empirical support for the SEC's continued usage of the comprehensive approach. Second, the rejection of the portfolio approach by the Basle Group, the EC, IOSCO, and the SEC has been misguided, and selection of the inferior building-block approach is imprudent and unwise. Third, the portfolio approach surely points the way ahead not just for equity trading books, but for the entire portfolio of positions held by securities firms or, for that matter, banks.

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