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Taking the risk out of systemic risk measurement I

by

Levent Guntay and Paul Kupiec¹

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ABSTRACT

An emerging literature proposes using conditional value at risk (CoVaR) and marginal expected shortfall (MES) to measure financial institution systemic risk. We identify two weaknesses in this literature: (1) it lacks formal statistical hypothesis tests; and, (2) it confounds systemic and systematic risk. We address these weaknesses by introducing a null hypothesis that stock returns are normally distributed. This allows us to separate systemic from systematic risk and construct hypothesis tests for the presence of systemic risk. We calculate the sampling distribution of these new test statistics and apply our tests to daily stock returns data over the period 2006-2007. The null hypothesis is rejected in many instances, consistent with tail dependence and systemic risk but the CoVaR and MES tests often disagree about which firms are potentially “systemic.” The highly restrictive nature of the null hypothesis and the wide range of firms identified as systemic makes us reluctant to interpret rejections as clear evidence of systemic risk. The introduction of hypothesis testing is our primary contribution, and the results highlight the importance of generalizing the approach to less restrictive stock return processes and to other systemic risk measures derived from return data.

Key Words: systemic risk, conditional value at risk, CoVaR, marginal expected shortfall, MES, systemically important financial institutions, SIFIs

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Taking the risk out of systematic risk measurement I

I. Introduction

A number of recent papers have used specific measures of stock return tail dependence as indicators of the “systemic risk” potential associated with individual large complex financial institutions.² This literature suggests that specific stock return tail dependence measures can be used as a basis to tax large complex financial institutions and penalize them for the systemic risk that they create [1,2], or alternatively, to indirectly tax these institutions by requiring enhanced regulatory capital and liquidity requirements that are calibrated using these tail dependence measures [3].

In this paper, we focus on two systemic risk measures that have been proposed in the literature: conditional value at risk (CoVaR) and marginal expected shortfall (MES). Both measure tail dependence in the stock returns of individual financial institutions and equate the magnitude of tail dependence estimates as a measure of systemic risk created by the institution in question.

The basic idea in the systemic risk literature is that, should a systemically important financial institution suffer a large loss and become distressed, it will shift the lower tail of the stock return distributions of other firms in the economy. The shift happens because the institution’s distress spreads throughout the financial sector and chokes off credit intermediation to the real economy. The claim is that the systemic risk potential of an institution can be measured using either CoVaR or MES applied to financial institution stock return data. CoVaR and MES differ on the exact set of conditioning events but each borrows a popular measurement technique from the risk management literature and applies it to conditional returns distributions as means for identifying and measuring a financial institution’s systemic risk.

The CoVaR measure of systemic risk proposed in the literature is the difference between two 99 percent VaR³ measures applied to the conditional return distribution of a portfolio of financial institutions: (1) the 99 percent CoVaR conditional on the single financial institution in question experiencing a return equal to its 1 percent quantile; and, (2) the 99 percent CoVaR conditional on the same individual institution experiencing a median return.⁴ The idea is that, should there be systemic risk potential, a near catastrophic loss by the financial institution in question will left-shift the 1 percent quantile of the conditional return distribution of a portfolio of financial firms. CoVaR is typically estimated using

² These papers include [1], [2], [3], and [6]. See [5] for a recent survey of this literature and [7] or [4] for a critical assessment.

³ In this literature, a 99 percent VaR measure is taken to be identical to the 1 percent quantile of the underlying return distribution.

⁴ CoVaR is very similar to the value at risk stress testing methodology developed in [8].

quantile regression on the grounds that such estimates are non-parametric and free from biases that may be introduced by inappropriately restrictive distributional assumptions.

Expected Systemic Shortfall (SES) and the Systemic Risk Index (SRISK) are transformations of the MES. MES is the expected shortfall calculated from a conditional return distribution for an individual financial institution. The institution's return distribution is conditioned on a large negative market return. SES and SRISK measures transform MES so that it approximates the extra capital the financial institution may need to survive a virtual market meltdown. SES and SRISK measures are based on MES and measures of the financial institution's capital and leverage. The primary input is the financial institution's MES which is typically estimated as the institution's sample expected stock return value on days when the market return realization is in its 5 percent lower tail. This measure is also non-parametric in the sense that the estimator requires no maintained hypothesis about the probability density that generates stock returns.

The existing literature asserts that when large complex financial institutions exhibit large CoVaR or MES estimates it is evidence that these institution have the potential to create significant systemic risk. Existing studies demonstrate the "power" of these systemic risk measures by showing that virtually all of the large financial institutions that required government assistance during the recent financial crisis (or failed) exhibited large CoVaR or SES measures immediately prior to the crisis. Moreover, the nonparametric nature of the methods that have been used to estimate CoVaR and the MES has been portrayed as positive attribute because they avoid the introduction of biases that may accompany inappropriate parametric distributional assumptions.

In our view, there are two glaring weaknesses in the existing CoVaR and MES systemic risk literature. One weakness is that the literature does not offer formal statistical hypothesis tests to identify systemic risk. A second weakness is that the CoVaR and MES measures are contaminated by systematic risk.⁵ Firms that have large systematic risk will have a tendency to produce large (negative) CoVaR and MES statistics even when there is no evidence of systemic risk in their returns.

Existing CoVaR and MES studies have thus far avoided the use of formal hypothesis tests. They do not specify a model for the null hypothesis of "no systemic risk" that is tested and rejected in favor of the alternative hypothesis that the institution is a source of systemic risk. Instead they argue it is not mere coincidence that the large complex institutions that failed or received government aid also had large MES or CoVaR measures prior to the onset of the crisis. For a literature that is based on relatively complex

⁵ See, for example [7] or [4].

statistical arguments, it is surprising that it chooses to eschew basic principles of classical statistical inference.

The nonparametric nature of the recommended estimators for the CoVaR and MES metrics has helped to obscure their underlying portmanteau nature. Adopting a classical view of statistical inference, under the null hypothesis of no systemic risk, the sample values of the CoVaR and MES statistics can only be generated by systematic (market) and idiosyncratic risks. Under the alternative hypothesis of systemic risk, the CoVaR and MES sample statistics will still be generated by systematic and idiosyncratic risk (perhaps largely so), but there will be an additional element of “systemic risk” in the returns data as well. The null hypothesis of no systemic risk should be rejected when the sample includes ample evidence that there is a large systemic risk component present in the sample return data. The lack of a well-defined null hypothesis in existing CoVaR and MES studies precludes the possibility of constructing a formal test statistic. Such a statistic is needed to identify when a sample of stock returns is sufficiently different from the null hypothesis so that it is appropriate to reject the null hypothesis of no systemic risk.

In this paper, we take a first step toward removing these shortcomings in the existing systemic risk literature. We consider the parametric formulation of CoVaR and MES measures under the null hypothesis that stock returns are a multivariate Gaussian process. The Gaussian return distribution is symmetric and exhibits tail independence meaning that, in the bivariate case, the probability of observing an extreme return in one dimension is not affected by an extreme return realization in the other dimension. If stock returns are Gaussian, there is scope for systemic risk. Under the null hypothesis of no systemic risk, we derive the closed form expressions for CoVaR and MES metrics and show that they are determined by systematic and idiosyncratic risk.

Because the Gaussian return distribution is symmetric and tail independent, parametric Gaussian CoVaR and MES statistics do not admit the possibility for systemic risk. However, they do provide a statistical mechanism for separating systemic risk from systematic risk and a basis for constructing hypothesis tests. To create a statistical test for systemic risk, we compare the CoVaR and MES non-parametric estimators proposed in the literature with their Gaussian parametric counterparts. Because the proposed non-parametric estimators do not require returns to be symmetric or tail independent, they may be able to detect the presence of systemic risk in stock returns.

By comparing the non-parametric sample estimates of CoVaR and MES to estimates of their parametric Gaussian sample counterparts, we remove the effects of systematic and idiosyncratic risk under the null hypothesis. We reject the null hypothesis of no systemic risk when the CoVaR and MES estimators produce larger negative values than their parametric sample counterparts. We determine the size of the

margin necessary to reject the null hypothesis of no systemic risk in favor of the alternative hypothesis by using critical values estimated from a small sample Monte Carlo study.

We apply our new statistical testing technique to historical stock returns taken from the two years prior to the financial crisis. We summarize our findings for various industries including banking (depositories), investment banking (broker dealers), insurance, retail trade, construction, and manufacturing. Every industry includes at least a few firms for which their CoVaR or MES tests statistics reject the null hypothesis at the 5 percent level and a number of industries include a large number of firms whose returns could be consistent with tail dependence and systemic risk.

Comparing the CoVaR and MES test statistics for individual firms, it is evident that the MES test identifies many more rejections compared to the CoVaR test. This finding could be related to the fact that the MES is based on a larger slice (5 percent) of the tail of the returns distribution compared to CoVaR (1 percent tail). However, this intuition cannot be completely correct as the quantile regression methodology uses all the sample data points to calculate 1 percent tail estimates. Still, it is well known that the estimation error in quantile regression estimates grows substantially in the extreme quantiles of the distribution and this fact certainly plays a role in the generation of our results.

Our tests identify a substantial number of firms whose returns generate CoVaR and MES test statistics that could be interpreted as evidence of systemic risk. While our hypothesis testing approach represents an important step forward in systemic risk measurement, the composite null hypothesis we use to develop the test statistics is too restrictive to allow us to identify the rejections as evidence of systemic risk. Stock returns can exhibit non-Gaussian behavior that may cause a rejection of the CoVaR and MES null hypotheses of no systemic risk even if returns do not exhibit tail dependence. If the CoVaR and MES measures are to be useful systemic risk indicators, these hypothesis tests must be generalized to accommodate stock return processes which are less restrictive than Gaussian.

The remainder of the paper is organized as follows. Section II provides a brief overview of the existing literature. Section III reviews the CoVaR and MES definitions and derives a closed-form expression for each under the null hypothesis that the market portfolio and individual stock returns are bivariate normally distributed. Section IV calculates the characteristics of CoVaR and MES measures for a broad cross section of stock returns using the nonparametric methods recommended in the literature and demonstrates that these measures are in part driven by systematic risk. Section V develops the proposed systemic risk test statistics for the CoVaR and MES measures and provides Monte Carlo Evidence on the small sample critical values of these test statistics. Section VI applies our proposed test statistics to a large sample of daily stock return data from 2006-2007. Section VII provides our summary and conclusions.

II. Literature Review

1. Conditional Value at Risk (CoVaR)

Let R_P be the return on a reference portfolio of stocks and R_j represent the return on an individual stock. Adrian and Brunnermeier [3] define the q-percent CoVaR measure for firm j to be the q-percent quantile of a reference portfolio's conditional return distribution, where the distribution is conditioned on the individual stock's return equal to its q-percent VaR value. Firm j's q-percent CoVaR is formally defined as:

$$Pr\left(R_P \leq CoVaR(R_{P|j}, q) \mid R_j = VaR(R_j, q)\right) = q \quad (1)$$

$\Delta CoVaR$ is the difference between the stock j's q-percent CoVaR and the stock's median CoVaR defined as stock j's CoVaR calculated conditional on a median market return.

$$\Delta CoVaR(R_{P|j}, q) = CoVaR(R_{P|j}, q) - CoVaR(R_{P|j}, 50\%) \quad (2)$$

Empirical estimates of CoVaR set "q" equal to 1-percent. Adrian and Brunnermeier [3] estimate CoVaR using quantile regressions but they also show that GARCH-based CoVaR estimates are similar.

Adrian and Brunnermeier [3] argue that $\Delta CoVaR$ measures how an institution contributes to the systemic risk of the overall financial system. They also estimate a measure they call "forward- $\Delta CoVaR$ " by projecting estimates of $\Delta CoVaR$ on bank-level characteristics. They show that forward- $\Delta CoVaR$ can explain more than 50 percent of the cross sectional covariance during the recent financial crisis. They conclude that forward- $\Delta CoVaR$ summarizes the expected contribution of a firm to the future systemic crisis.

2. Marginal Expected Shortfall (MES)

Acharya, Pedersen, Phillipon, and Richardson [2] define MES as the marginal contribution of firm j to the expected shortfall of the financial system. Formally, MES for firm j is the expected value of the stock return \tilde{R}_j conditional on the market portfolio return \tilde{R}_M being at or below the sample p-percent quantile.

$$MES(R_j, p) = E(R_j | R_M < VaR(R_M, p)) \quad (3)$$

Higher levels of MES imply that firm j is more likely to be undercapitalized in the bad states of the economy and thus contribute more to the aggregate risk of the financial system.

Acharya, Pedersen, Phillipon, and Richardson [2] use a 5 percent market return threshold and estimate MES by taking a selected-sample average. Brownlees and Engle [6] and Acharya, Engle and Richardson [1] use dynamic volatility and correlation models to estimate MES from firm and the market returns.

In empirical tests Acharya, Pedersen, Phillipon, and Richardson [2] show that MES calculated over the 2006-2007 period can predict stock returns during the crisis. A variant of MES based on Credit Default Swap returns seems to detect the failed institutions in different financial sectors. However, these results should be interpreted with caution and do not necessarily imply that MES is predicting systemically risk institutions. Under weak assumptions one can show that MES is equal to market beta times the expected shortfall on the market. Thus, MES shows high correlation with systematic risk and is not necessarily a systemic risk proxy.

3. *Systemic Expected Shortfall (SES)*

Acharya, Pedersen, Phillipon, and Richardson [2] define Systemic Expected Shortfall (SES) as the expected undercapitalization of bank i when the aggregate banking system as a whole is undercapitalized. Thus, ex-ante SES aims to measure each bank's expected contribution to a future systemic crisis.

Acharya, Engle, and Richardson [1] rename SES as SRISK and formally define SRISK for firm j by:

$$SRISK_j = \max(0, Equity_j [K Leverage_j - (1 - K) \exp(-18 MES_j)]) \quad (4)$$

where equity denotes market capitalization of firm j , K is the minimum capital requirement for banks, and leverage is the book value of bank j 's debt divided by equity. Acharya, Engle, and Richardson [1] use extreme value theory to argue that there is a direct link between MES, which is estimated on moderately bad days, and SRISK which is intended to measure risks associated with the extreme event of a systemic banking crisis.

Stock returns enter the SES calculation (or SRISK measure) only through the MES statistic. SES modifies the MES statistic so that a bank's systemic risk is related to its stock return tail dependence, but the strength of the systemic risk also depends on the bank's current capital position relative to the projected capital the bank would need to survive a financial crisis. The latter amount is estimated by comparing a bank's current capital position to a scaled-up MES estimate where the scaling adjusts the sample MES estimates to account for true financial crisis conditions.⁶

⁶ MES is estimated on days when the market portfolio realization is in the lower 5 percent tail. This within-sample condition is likely less severe than the returns associated with a financial crisis. Scaled MES is an approximation for the expected losses on financial crisis days. It is based on an extreme value approximation that links expected losses under more extreme events to sample MES estimates based on less restrictive conditions.

MES only depends on stock return moments while SRISK/SES incorporates additional information about firm size and leverage. Since the underlying intuition in these systemic risk measures is that systemic risk potential can be measured using information compounded in observed stock return distributions, we focus our interest on the MES component of the SES risk measure.

III. CoVaR and MES under a Gaussian Model of Stock Returns

There is a long history of modeling stock returns as random variables with multivariate Gaussian density functions. While a large modern literature emphasizes that stock returns have fatter tails than can be justified under the Gaussian model, the multivariate Gaussian model still is a reasonable place to begin the development of formal CoVaR and MES hypothesis tests that are capable of detecting systemic risk.

Let \tilde{R}_P represent the return on a portfolio of stocks and \tilde{R}_j represent the return on an individual stock. When $(\tilde{R}_j, \tilde{R}_P)$ have a multivariate normal distribution, then their conditional distributions are also normal random variables,

$$\tilde{R}_j | \tilde{R}_P = r_{Pi} \sim \Phi \left[\mu_j + \rho \frac{\sigma_j}{\sigma_P} (r_{Pi} - \mu_P), (1 - \rho^2) \sigma_j^2 \right] \quad (5a)$$

$$\tilde{R}_P | \tilde{R}_j = r_{ji} \sim \Phi \left[\mu_P + \rho \frac{\sigma_P}{\sigma_j} (r_{ji} - \mu_j), (1 - \rho^2) \sigma_P^2 \right] \quad (5b)$$

Where $\Phi(a, b)$ represent the Gaussian distribution function with mean “a” and variance “b”, μ_j and μ_P represent the individual (univariate) return means, σ_j^2 and σ_P^2 represent the individual return variances and ρ represents the correlation between returns.

1. Gaussian (Parametric) CoVar

CoVaR can be measured in two ways. One CoVaR measures the conditional VaR of a reference portfolio conditional on an individual stock experiencing an extreme left-tail return event. A second possible CoVaR calculation measures the conditional value at risk of an individual stock conditional on the reference portfolio experiencing an extreme left-tail return event. We will derive the closed form expression for both measures.

First we derive the CoVaR measure for the reference portfolio conditioned on the extreme negative return of an individual stock. The conditional distribution function for \tilde{R}_P conditional on \tilde{R}_j equal to its 1 percent value at risk is,

$$\tilde{R}_P | \tilde{R}_j = \Phi^{-1}(.01, \tilde{R}_j) \sim \tilde{R}_P | \tilde{R}_j = r_{ji} \sim \Phi \left[\mu_P + \rho \frac{\sigma_P}{\sigma_j} (r_{ji} - \mu_j), (1 - \rho^2) \sigma_P^2 \right]. \quad (6)$$

So the 99 percent CoVaR for the portfolio conditional on \tilde{R}_j equal to its 99 percent VaR,

$$CoVar(\tilde{R}_P | [\tilde{R}_j = \Phi^{-1}(.01, \tilde{R}_j)]) = \mu_P - \rho \frac{\sigma_P}{\sigma_j} (2.32635 \sigma_j) - 2.32635 \sigma_P \sqrt{1 - \rho^2}, \quad (7)$$

The conditional return distribution for the portfolio, conditional on \tilde{R}_j equal to its median is,

$$\tilde{R}_P | \tilde{R}_j = \Phi^{-1}(.50, \tilde{R}_j) \sim N[\mu_P, (1 - \rho^2) \sigma_P^2]. \quad (8)$$

Consequently, the CoVaR for the portfolio with \tilde{R}_j evaluated at its median return is,

$$CoVar(\tilde{R}_P | [\tilde{R}_j = \Phi^{-1}(.50, \tilde{R}_j)]) = \mu_P - 2.32635 \sigma_P \sqrt{1 - \rho^2}, \quad (9)$$

and so the contribution CoVaR measure with $\beta_{jP} = \frac{Cov(\tilde{R}_j, \tilde{R}_P)}{\sigma_P^2}$ is given by,

$$\Delta CoVar(\tilde{R}_P | [\tilde{R}_j = \Phi^{-1}(.01, \tilde{R}_j)]) = -\beta_{jP} * 2.32635 \frac{\sigma_P^2}{\sigma_j} \quad (10a)$$

$$= -\rho * 2.32635 \sigma_P \quad (10b)$$

Reversing the order of the conditioning variable (i.e., the CoVaR for \tilde{R}_j conditional on \tilde{R}_P equal to its 99 percent VaR loss), it is straight-forward to show that the so-called exposure CoVaR measure is,

$$\Delta CoVar(\tilde{R}_j | [\tilde{R}_P = \Phi^{-1}(.01, \tilde{R}_P)]) = -\beta_{jP} * 2.32635 \sigma_P, \quad (11a)$$

$$= -\rho * 2.32635 \sigma_j \quad (11b)$$

Regardless of which return is used to do the conditioning, both CoVaR measures are strictly proportional to the correlation between of the stock returns.

2. *Gaussian (Parametric) MES*

The marginal expected shortfall measure is the expected shortfall calculated from a conditional return distribution. In Acharya, Pedersen, Philippon and Richardson [2], the conditioning event can be either (a) the market return less than or equal to is 5 Percent VaR value, or (b) the return on the portfolio of bank stocks less than or equal to its 5 percent VaR value.

Under the assumption of multivariate normality, the conditional stock return is normally distributed, and consequently,

$$E(\tilde{R}_j | \tilde{R}_P = r_{Pi}) = \mu_j - \rho \frac{\sigma_j}{\sigma_P} \mu_P + \rho \frac{\sigma_j}{\sigma_P} r_{Pi}. \quad (12)$$

Now, if \tilde{R}_P is normally distributed with mean μ_P and standard deviation σ_P , then the expected value of the market return truncated above a value “b” is,

$$E(\tilde{R}_P | R_P < b) = \mu_P - \sigma_P \left[\frac{\phi\left(\frac{b-\mu_P}{\sigma_P}\right)}{\Phi\left(\frac{b-\mu_P}{\sigma_P}\right)} \right], \quad (13)$$

lower 5 percent tail value, $b = \mu_P - 1.645\sigma_P$, and the expected shortfall measure is,

$$E(\tilde{R}_j | \tilde{R}_P < VaR(\tilde{R}_P, 95\%)) = \mu_j - \rho \sigma_j \left[\frac{\phi(-1.645)}{\Phi(-1.645)} \right] \quad (14a)$$

$$= \mu_j - 2.062839 \sigma_M \beta_{jP} \quad (14b)$$

where the constant (2.062839) is a consequence of the 5 percent tail conditioning on the market return, i.e., $\left[\frac{\phi(-1.645)}{\Phi(-1.645)} \right] = 2.062839$.

IV. Are CoVaR and MES Measures of Systemic Risk?

The existing CoVaR and MES literature focuses on the stock returns of large financial institutions just prior to the crisis. It argues that CoVaR and MES are measures of systemic risk because there is a high correspondence between institutions that had large MES and CoVaR measures immediately prior to the crisis and institutions that required extensive government capital injections or failed. While this justification can seem convincing in the context of a selected sample of financial firms, the argument becomes less convincing when it is viewed in a broader context. CoVaR and MES statistics can be calculated for all firms with stock return data.

In this section we calculate the MES and CoVaR measures using the nonparametric methods recommended in the literature for all CRSP stocks using daily returns data for the sample period 2006-2007, the years immediately prior to onset of the financial crisis. Our reference portfolio for these calculations is the CRSP equal-weighted market index return. We measure the CoVaR for each firm using a 1 percent quantile regression of the equally-weighted market portfolio return on the individual stock's daily returns. We measure MES for each stock as the expected stock returns on days when the equally-weighted market portfolio experiences a return in the 5 percent lower tail of its sampling distribution.

Table 1 lists the fifty companies that exhibit the largest CoVaR measures in descending order of “systemic risk” as indicated by the magnitude of the companies’ 1-percent CoVaR statistic. The CoVaR statistic measures the 1-percent quantile of the conditional return distribution of the equally weighted

market portfolio. The conditioning event is the stock in question experiences a return equal to the 1-percent quantile of its unconditional return distribution.

Most of the firms listed in Table 1 are part of the “real economy” and have nothing to do with the financial services sector. Among the firms listed in Table 1 are 6 financial firms: Citizens First Bancorp, Ameriprise Financial Inc, NASDAQ Stock Market Inc, Legg Mason Inc, Fox Chase Bancorp, and Medallion Financial Corp. It is very unlikely that anyone would view any of these firms as “systemically important.” The financial firm with the largest CoVaR statistic, Citizens First Bancorp, has less than half the indicated systemic risk of Proquest, the company with the largest CoVaR systemic risk measure among traded firms.

Table 2 lists, in descending order, the fifty companies with the largest MES systemic risk measures. MES is calculated as the literature suggests, using the sample expected value of each company’s stock return on days when the market return experiences a return that is in 5-percent left hand tail of observed stock returns within the sample period. While the top-fifty MES firms are still dominated by the real sector, the MES does generate a list of “high risk” financial firms that did subsequently flounder during the crisis. CompuCredit, E-trade, Countrywide Financial, IndyMac, BankUnited Financial, Net Bank, and Accredited Home Lenders all experienced serious distress or failed subsequent to the onset of the financial crisis. Still, none of these firms are exceptionally large and none was considered to be considered as systemically important or “too-big-to-fail” during the crisis. Again, the firm with the largest MES is not a financial firm, and its MES is twice the magnitude of the highest scoring financial firm.

Notwithstanding the issue of whether CoVaR or MES statistics are legitimate measures of systemic risk, the parametric Gaussian expressions for both measures suggest that much of the inter-firm variation in these measures is related to differences in individual firms’ systematic risks, or the correlation that all firms’ returns have with an underlying common factor. A significant share of the cross sectional variation in CoVaR and MES statistics can be attributed to variation in firms’ systematic and idiosyncratic risks.

Figure 1 shows the fit of a regression of individual stock’s MES on their market model beta coefficients when both parameters are estimated from daily return data over the sample period 2006-2007. The simple market model beta coefficient (systematic market risk) explains nearly three-quarters of the cross-section variation in MES.

The parametric Gaussian expression for CoVaR shows that CoVaR is determined, at least in part, by a stock’s correlation with the reference portfolio return. If we use the equally-weighted market portfolio as the benchmark of comparison, then CoVaR will depend on the correlation of the stock with the market portfolio (or alternatively the market model beta coefficient multiplied by the ratio of the market portfolio

return variance to the standard deviation of the individual stock's return). Figure 2 shows the fit of a cross-sectional regression of individual contribution CoVaR estimates on individual stock's sample correlation estimates with equally-weighted market portfolio returns. This regression explains nearly 30 percent of the observed cross-sectional variation in the sample CoVaR estimates. For both the MES and the CoVaR statistics, the greater a firm's systematic risk, the greater the potential that it will produce a large value CoVaR or MES statistic.

In order to construct a CoVaR or MES-based test for systemic risk, it is necessary to remove the effects of a firm's systematic risk, and the case of CoVaR, its non-systemic idiosyncratic risk as well. In the next section, we construct CoVaR and MES-based test statistics that remove the effects systematic risk and common factor correlation that compounded in the "raw" CoVaR and MES measures.

IV. Test Statistics for Systemic Risk

In this section we construct classical hypothesis tests statistics for the CoVaR and MES measures that can be used to test whether an individual firm's returns have characteristics that could be generated by systemic risk. To construct these tests, we adopt the null hypothesis that individual stock returns have Gaussian distributions. Under this assumption we have already developed the parametric representations of CoVaR and MES in Section III.

To construct our hypothesis test statistics, we estimate CoVaR and MES in two ways and base our test statistic on a scaled version of the difference between the two CoVaR and MES estimators. Under the null hypothesis, the parametric MES and CoVaR estimators are unbiased and efficient since they are based on the maximum likelihood estimates. Similarly, under the null hypothesis the alternative non-parametric CoVaR and MES estimators are unbiased, but they are not efficient as they do not use any information on the parametric form of the stock return distribution. Under the alternative hypothesis, the nonparametric CoVaR and MES estimators can have expected values that differ from their parametric Gaussian counterparts. Under the alternative hypothesis, the magnitude of the nonparametric estimators will reflect tail-dependence in the sample data while their parametric Gaussian do not. Thus, under the alternative hypothesis that stock returns are in part driven by systemic risk, the nonparametric estimators should produce larger (more negative) CoVaR and MES statistics.

Under the null hypothesis, the difference between the two estimators (nonparametric and parametric) has an expected value of 0, but it has sampling error that can be large or small in any given sample. An important issue is whether the variance of this sampling error is independent of the characteristics of the stock and portfolio returns that are being analyzed. It turns out that the difference between the non-parametric and the Gaussian parametric estimators has a sampling error that depends on both the returns

correlation and the idiosyncratic risk of the individual stock. We can control for one of these sources of sampling error by normalizing the differences between the nonparametric and the parametric measures, but we are left with the returns correlation as a “nuisance” parameter that must be controlled when we construct our small sample Monte Carlo test statistic simulations.

Let \widehat{CoVaR} represent the quantile regression estimator for the contribution CoVaR measure. Let \widehat{CoVaR} represent the sample parametric Gaussian estimator for CoVaR. Define the CoVaR test statistic as,

$$\kappa_{CoVaR} = \frac{\widehat{CoVaR} - \widehat{CoVaR}}{\widehat{CoVaR}}. \quad (15)$$

Under the Gaussian null hypothesis, it can be easily demonstrated the sampling distribution of κ_{CoVaR} depends only on the correlation parameter between the stock returns and the returns on the reference portfolio. Under the Gaussian null hypothesis, since there is no tail dependence, the direction of conditioning will not matter. That is, it will not matter if you condition a reference portfolio return on an extreme return realization of an individual stock (so-called contribution CoVaR), or you calculate an individual stock’s CoVaR conditioned on an extreme reference portfolio return (so-called exposure CoVaR), the sampling distribution for the test statistic is identical.

Under the alternative hypothesis of systemic risk, \widehat{CoVaR} is expected to produce a larger negative value than \widehat{CoVaR} , and since both are negative, systemic risk is in evident when the test statistic produces a large positive value. Statistical significance is determined by comparing the test value for κ_{CoVaR} with its sampling distribution under the null. When the test value of κ_{CoVaR} is in the far right-hand tail of its sampling distribution, we can reject the null hypothesis of no systemic risk. The critical value used to establish statistical significant determines the type 1 error rate for the test. For example, rejecting the null hypothesis for test values at or above the 95 percent quantile of the sampling distribution for κ_{CoVaR} is consistent with a 5 percent type 1 error or a 5 percent chance of rejecting a true null hypothesis.

In Table 3 and Table 4 we report the small sample distribution 1, 5 and 10 percent critical value estimates for the κ_{CoVaR} for 10 different portfolio-stock return correlation assumptions. The critical values are calculated using Monte Carlo Simulation⁷ for a sample size of 500 observations, the equivalent of about two years of daily data. We focus on a two-year estimation window because the characteristics of financial institutions change very quickly over time through mergers and acquisitions, especially for the largest institutions. The critical value statistics we report are based on 25,000 Monte Carlo simulations.

⁷ We use the quantile regression package QUANTREG in R.

Table 3 reports the critical values for the κ_{CoVaR} statistic calculated for the contribution CoVaR (i.e., the reference portfolio return VaR conditional on the individual stock at its 1 percent quantile). Table 4 reports the small sample critical values for the κ_{CoVaR} statistic calculated for the exposure CoVaR (i.e., stock return VaR conditional on the reference portfolio return at its 1 percent quantile). A comparison of Tables 3 and 4 will show that the critical values in these tables are very close and they will converge if we increase the precision of our Monte Carlo estimators. The critical values differ most in the low correlation buckets because these buckets inherently have the largest estimation error. Under the null hypothesis of a Gaussian distribution, the quantile regression will produce very imprecise estimates when there is little correlation between the returns, and so the sampling distribution of the test statistic will have a large variance.

Let \overline{MES} represent the non-parametric estimator for MES. The literature defines it as the average individual stock return on days when the reference portfolio has a return realization in its lower tail. We condition on reference portfolio returns in the 5 percent tail. Let \widehat{MES} represent the sample parametric Gaussian estimator for MES and $\hat{\sigma}_i$ represent the sample standard deviation of the individual stock return in the calculation. We define the MES test statistic as,

$$\kappa_{MES} = \frac{\overline{MES} - \widehat{MES}}{\hat{\sigma}_i} \quad (17)$$

Under the alternative hypothesis of systemic risk, \overline{MES} is expected to produce a larger negative number compared to \widehat{MES} , and since $\hat{\sigma}_i$ is positive, systemic risk is in evidence when the test statistic produces a large negative value. As in the CoVaR case, this test statistic still depends on the correlation between the stock and the reference portfolio, so correlation is a “nuisance” parameter that enters into the sampling distribution critical value calculations. Table 4 reports estimates for the 1, 5, and 10 percent critical values of the κ_{MES} statistic based on a sample size of 500 observations and 25,000 Monte Carlo replications for 10 different correlation assumptions.

VI. Systemic Risk Test Application to 2006-2007 Stock Returns Data

1. Sample of Stock Returns

We start with all US firms identified in the intersection of CRSP and Compustat databases between 2006 and 2007.⁸ We exclude security issues other than common stock such as ADRs and REITs. We eliminate firms if: i) the market capitalization is less than \$100 million; ii) it has less than 250 daily returns over the

⁸ We required data in both CRSP and Compustat because we had anticipated the need to relate systemic risk measures to firm characteristics typically measured using accounting data. For this draft, we have not used the accounting information.

sample horizon; or iii) total assets information is missing in the Compustat database. These filters result in 3475 institutions. Table 1 describes the breakup of the sample by 12 financial and nonfinancial industries.

2. *Estimation Methodology*

a. Nonparametric CoVaR

We estimate the nonparametric ΔCoVaR statistic, $\Delta\widehat{\text{CoVaR}}$, in three steps:

- We run a 1-percent quantile regression of the CRSP equally weighted market return, R_M on R_j and estimate $\widehat{\beta}_q$, the stock return coefficient in the quantile regression.
- Estimate the 1-percent sample quantile and the median of the stock return, R_j , $\widehat{\text{VaR}}(R_j, q)$ and $\widehat{\text{VaR}}(R_j, 0.50)$.
- Nonparametric ΔCoVaR estimator is defined as:

$$\Delta\widehat{\text{CoVaR}}(R_M | R_j = \text{VaR}(R_j, q)) = \widehat{\beta}_q (\widehat{\text{VaR}}(R_j, q) - \widehat{\text{VaR}}(R_j, 0.50)) \quad (18)$$

We estimate our parametric ΔCoVaR statistic, $\Delta\widehat{\text{CoVaR}}$, using equation (11) and the sample moments of individual stock returns and the equally-weighted market portfolio returns.

b. Nonparametric MES

We estimate nonparametric MES, $\widehat{\text{MES}}$, as the average of individual stock returns on sample subset of days that correspond with the 5% worst days of the equally-weighted broad stock market index.

$$\widehat{\text{MES}}(R_j, 5\%) = \frac{\sum R_j I(R_m < \text{VaR}(R_m, 5\%))}{\sum I(R_m < \text{VaR}(R_m, 5\%))} = \frac{1}{N} \sum_{R_m < \text{VaR}_{5\%}} R_j \quad (19)$$

where $I(\cdot)$ is the indicator function and N is the number of 5% worst days for the market.

We measure parametric MES, $\widehat{\text{MES}}$, using expression (14) and sample moments for individual stock returns and the returns on the equally-weighted market portfolio.

3. *Estimation Results*

Unlike most CoVaR and MES studies, we do not claim that the relative magnitudes of our κ_{CoVaR} or κ_{MES} test statistic are meaningful measures of the amount of systemic risk generated by an institution. Our tests statistics evaluate whether the data appear to be consistent with the null hypothesis of Gaussian returns which precludes the presence of tail dependence caused by systemic risk. If we fail to reject the null hypothesis, the firm returns do not contain a systemic risk component if they seeming produce “large” CoVaR or MES statistics. In the opposite event when the null hypothesis is rejected, it may be

because there is a systemic risk component in returns or, alternatively, returns may be just be inconsistent with a Gaussian distribution but fully consistent with some other distribution that precludes systemic risk. We fully recognize that there are potentially several reasons why we these tests might reject the null hypothesis, and the presence of systemic risk is just one possibility.

κ_{CoVaR} Test Results

We report the results of the contribution CoVaR test by industry. Figure 3 summarizes the CoVaR test results for all depository institutions. In the Figure 3 and figures that follow, the green line represents the 5 percent critical value of the test and the red line plots the 10 percent critical test value.

Figure 3 shows that relatively few depository institutions reject the null hypothesis at standard statistical levels. Table 7 lists the 20 depository institutions for which the null hypothesis is rejected at the 5 percent level of the test. While the CoVaR test results suggest that these institutions could be sources of systemic risk, none of them is large, and likely no one would identify any of them as a systemically important institution.

Figure 4 summarizes the CoVaR test results for the insurance industry. Again, relatively few firms reject the null hypothesis at the 5 percent level, and these 12 firms are listed in Table 8. Other than Metlife, which has been a potential candidate for systemically important designation by the Financial Stability Oversight Council, there are no firms which would be immediately identified as potential sources of systemic risk.

Figure 5 summarizes the results for the retail trade industry. Within this industry, 12 firms produce rejections of the null hypothesis at the 5 percent level and they are listed in Table 9. Notable potential sources of systemic risk identified by the test include Caribou Coffee, Dennys, and the retail drug store chains CVS and Walgreens. For those who may be curious, the Starbucks test statistic was nowhere the standard threshold of statistical significance.

Figure 6 summarizes the test results for the construction industry. Within this industry, only two home building firms trigger a rejection of the null hypothesis at the 5 percent level. These firms are listed in Table 10.

Figure 7 summarizes the CoVaR test statistics results for the manufacturing industry. This industry includes 112 firms that violated the null hypothesis at the 5 percent level and thereby could be potential sources of systemic risk. The list appears in Table 11. While the list includes easily identifiable defense contractors IBM, Raytheon, General Dynamics, Lockheed Martin and DuPont, and the oil companies Sunoco and Armada Hess, it also includes Hershey, Liz Claiborne and Del Monte Foods. While one

might be able to make an argument that some of these firms are systemically important, there is no obvious systematic link to link to systemic risk in this long list of names.

κ_{MES} Test Results

The MES is much less selective in identifying firms that are potential sources of systemic risk. That is to say, the MES test identifies a lot of firms as firms that have system risk potential.

Figure 8 summarizes the MES test results for depository institutions. Again, in Figure 8 and the figures that follow, the green line represents the 5 percent critical value for the test statistic and the red line is the 10 percent critical value. Recall that the MES test rejects the null hypothesis when the test statistic is a large negative value, or values below the critical value lines.

The MES test identifies 125 depository institutions as potential sources of systemic risk. The 125 institutions which reject the null hypothesis at the 5 percent level are reported in Table 12. This extensive list includes a number of large institutions that are now considered to be systemically important under the legislative rules of the Dodd-Frank Act, and also it includes a number of institutions that failed during the financial crisis.

Figure 9 summarizes the insurance industry MES test results. The test identifies 60 firms that reject the null hypothesis at the 5 percent level and are thereby potential sources of systemic risk. The list of these 60 firms appears in Table 13 and it includes Prudential Financial and AIG, two firms that have already been designated as systemically important institutions, as well as Metlife, a third insurance firm that is being considered for this designation.

Figure 10 summarizes the MES test results for the retail trade industry. Again, many firms have stock returns that violate the null hypothesis at the 5 percent level. Similar to the CoVaR test, Caribou Coffee and Dennys make the list, only under the MES test they are joined by Jack in the Box, McDonalds, Ruby Tuesdays and Wendys International in the fast food category, and Sears, Walmart and Federated Department Stores among many other recognizable company names.

Figure 11 summarizes the results for the construction industry. There are only 7 firms in this industry whose returns reject the null hypothesis at the 5 percent level of the test. The names of these firms appear in Table 15 and are entirely different from the homebuilding firms identified by the CoVaR construction industry test results.

Finally, Figure 12 summarizes the MES test results for the manufacturing industry. Similar to the industry results for the CoVaR test, the manufacturing industry contains many firms whose returns trigger a rejection of the null hypothesis. The firms that that generate a rejection of the null hypothesis at the 5

percent level are listed in Tables 16a and 16b. There are 284 firms and these include many easily recognizable names including Ford Motor, General Motors, Alcoa, Coca Cola, and Cisco Systems as well as many of the same firms identified by the CoVaR test.

In our final table, Table 17, we illustrate how these two different test statistics compare when evaluating individual companies. In Table 17, we report the outcomes of the MES and CoVaR tests for the 25 largest depository institutions measured by stock market capitalization. Many of the surviving institutions from this list have been legally designated as systemically important institutions (by virtue of size) by the Dodd-Frank Act. The results in Table 17 clearly show marked differences in the firms that are identified by the two alternative tests. All of these large depository institutions produce MES test statistics that exceed (are more negative than) the 5 percent critical value threshold. In contrast, only one of these institutions, Bank of America, produces a CoVaR test statistic that is close to a critical test value, and Bank of America it is only statistically significant at the 10 percent level.

VII. Summary and Conclusions

In this paper, we develop a new methodology to control for systematic risk biases inherent in CoVaR and MES risk measures and construct formal classical hypothesis tests for the presence of systemic risk. The methodology and test statistics are based on the Gaussian return model of stock returns. We use Monte Carlo simulation to estimate the critical values of the sampling distributions of our proposed test statistics and use these critical values to test for evidence of systemic risk in a broad cross section of company stock returns using daily return data over the period 2006-2007. Our results find important difference between these alternative systemic measures. The MES test is much more likely to indicate that an individual firm's stock returns signal the possibility of systemic risk.

The test statistics we develop allow for formal hypothesis tests to detect systemic risk, tests which heretofore have been absent from the literature. Our test statistics do not provide an ideal solution to the problems that we have identified because they are almost certainly constructed using an overly-restrictive null hypothesis. Instead, they represent a first step toward improving statistical inference in the systemic risk measurement literature. They also provide a useful benchmark for evaluating the results reported in existing studies. Future research should be focused on generalizing this approach to allow for more flexible stock return generating processes under the null hypothesis and to extend the approach to other systemic risk measures that use securities returns.

References

- [1] Acharya, V.; Engle, R.; Richardson, M., 2012. “Capital Shortfall: A New Approach to Ranking and Regulating Systemic Risks”, *The American Economic Review* 102, 59-64.
- [2] Acharya, V. V., Pedersen, L., Philippon, T., and Richardson, M., 2010. “Measuring Systemic Risk”, Technical report, Department of Finance, NYU Stern School of Business.
- [3] Adrian, T. and Brunnermeier, M. K., 2011. “CoVaR”, FRB of New York. Staff Report No. 348.
- [4] Benoit, S. G. Colletaz, C. Hurlin, and C. Perignon, 2012. “A Theoretical and Empirical Comparison of Systemic Risk Measures.” Working Paper, University of Orleans, France.
- [5] Bisias, D., Flood, M., Lo, A., and Valavanis, S., 2012. A survey of systemic risk analytics. U.S. Department of Treasury, Office of Financial Research Working Paper.
- [6] Brownlees, C. and Engle, R., 2012. “Volatility, Correlation and Tails for Systemic Risk Measurement”, Working Paper, New York University.
- [7] Kupiec, Paul, and Levent Guntay, 2012. “Discussion of Acharya, V.; Engle, R.; Richardson, M., ‘Capital Shortfall: A New Approach to Ranking and Regulating Systemic Risks,’ American Economic Association Meetings, Chicago, Ill., January 2012.
- [8] Kupiec, Paul, 1998. “Stress Testing in a Value at Risk Framework,” *The Journal of Derivatives*, Vol. 6, No. 1.

Table 1: The Fifty Most "Systemically Risky" Firms as Ranked by their Contribution CoVaR Measure

Rank	Company Name	CoVar Estimate	Industry	Market Cap (\$thous)
1	PROQUEST CO	-0.03694	Manufacturing	841,624
2	TETRA TECHNOLOGIES INC	-0.02315	Manufacturing	1,156,865
3	NEWSTAR FINANCIAL INC	-0.02198	Other Financial	610,357
4	ISILON SYSTEMS INC	-0.02164	Manufacturing	1,397,388
5	COMVERSE TECHNOLOGY INC	-0.02156	Manufacturing	5,377,373
6	VENOCO INC	-0.01951	Mining	725,781
7	TITAN INTERNATIONAL INC ILL	-0.01919	Manufacturing	337,874
8	DOVER CORP	-0.01916	Manufacturing	8,408,696
9	ROBERT HALF INTERNATIONAL INC	-0.01897	Services	6,383,069
10	NEOWARE SYSTEMS INC	-0.01896	Manufacturing	428,482
11	MATTSON TECHNOLOGY INC	-0.01892	Manufacturing	529,285
12	VALERO ENERGY CORP NEW	-0.01884	Manufacturing	33,630,793
13	MURPHY OIL CORP	-0.01839	Manufacturing	10,341,498
14	CONSTELLATION BRANDS INC	-0.01789	Manufacturing	5,124,188
15	CAVALIER HOMES INC	-0.0177	Manufacturing	117,486
16	CITIZENS FIRST BANCORP INC	-0.01757	Depository Institutions	193,358
17	M S C INDUSTRIAL DIRECT INC	-0.01747	Manufacturing	1,931,327
18	GATEHOUSE MEDIA INC	-0.01742	Manufacturing	779,120
19	SMURFIT STONE CONTAINER CORP	-0.01741	Manufacturing	3,491,279
20	AMERIPRISE FINANCIAL INC	-0.01734	Broker Dealers	10,523,231
21	SOUTHERN COPPER CORP	-0.01725	Mining	10,211,734
22	PARKER HANNIFIN CORP	-0.01691	Manufacturing	7,982,404
23	CATERPILLAR INC	-0.01683	Manufacturing	39,316,022
24	NASDAQ STOCK MARKET INC	-0.01677	Broker Dealers	3,014,983
25	TECH DATA CORP	-0.01676	Wholesale Trade	2,263,077
26	A M R CORP DEL	-0.01672	Transportation, Communication, Utilities	3,923,425
27	MOSAIC COMPANY	-0.01655	Manufacturing	5,721,570
28	ORMAT TECHNOLOGIES INC	-0.01647	Transportation, Communication, Utilities	885,306
29	CIMAREX ENERGY CO	-0.01647	Mining	3,697,108
30	LEGG MASON INC	-0.01645	Broker Dealers	13,772,771
31	U A L CORP	-0.01645	Transportation, Communication, Utilities	3,322,732
32	WESTERN REFINING INC	-0.01641	Manufacturing	1,235,175
33	KOMAG INC	-0.01633	Manufacturing	1,045,095
34	HOME DIAGNOSTICS INC	-0.01632	Manufacturing	221,696
35	CIRCOR INTERNATIONAL INC	-0.01624	Manufacturing	410,897
36	FREEPORT MCMORAN COPPER & GOI	-0.0162	Mining	10,448,800
37	COOPER CAMERON CORP	-0.01617	Manufacturing	4,948,689
38	ROWAN COMPANIES INC	-0.01612	Mining	4,173,826
39	PROCENTURY CORP	-0.01611	Insurance	140,565
40	FOX CHASE BANCORP INC	-0.0161	Depository Institutions	190,145
41	DYNAMEX INC	-0.01605	Transportation, Communication, Utilities	218,534
42	MEDALLION FINANCIAL CORP	-0.01597	Other Financial	192,338
43	STILLWATER MINING CO	-0.01592	Mining	1,090,884
44	CLEVELAND CLIFFS INC	-0.01586	Mining	2,030,187
45	PULTE HOMES INC	-0.01584	Construction	10,659,344
46	ALLETE INC	-0.01582	Transportation, Communication, Utilities	1,371,347
47	C B S CORP NEW	-0.01581	Transportation, Communication, Utilities	18,522,588
48	SEACOR HOLDINGS INC	-0.0158	Transportation, Communication, Utilities	1,737,292
49	IDEX CORP	-0.01577	Manufacturing	2,166,488
50	OIL STATES INTERNATIONAL INC	-0.01576	Manufacturing	1,699,791

Table 2: The Fifty Most "Systemically Risky" Firms as Ranked by the MES Measure

Rank	Company Name	MES Estimate	Industry	Market Cap (\$thous)
1	ESCALA GROUP INC	-0.103	Services	577,964
2	FREMONT GENERAL CORP	-0.07126	Insurance	1,833,178
3	CHINA PRECISION STEEL INC	-0.06546	Manufacturing	290,057
4	CRAWFORD & CO	-0.05913	Insurance	143,984
5	STANDARD PACIFIC CORP NEW	-0.0556	Construction	2,601,460
6	POPE & TALBOT INC	-0.05518	Manufacturing	132,429
7	TRIAD GUARANTY INC	-0.05498	Insurance	651,533
8	COMPUCREDIT CORP	-0.0548	Other Financial	2,139,233
9	W C I COMMUNITIES INC	-0.0548	Construction	1,230,990
10	EMPIRE RESOURCES INC DEL	-0.05431	Wholesale Trade	101,814
11	BEAZER HOMES USA INC	-0.05415	Construction	3,089,545
12	E TRADE FINANCIAL CORP	-0.05316	Broker Dealers	7,829,131
13	RADIAN GROUP INC	-0.05297	Insurance	4,804,772
14	I C O GLOBAL COMMS HLDGS LTD DE	-0.05271	Transportation, Communication, Utilities	885,402
15	BADGER METER INC	-0.05265	Manufacturing	270,843
16	ACCREDITED HOME LENDERS HLDG I	-0.0526	Other Financial	1,050,682
17	BANKUNITED FINANCIAL CORP	-0.05186	Depository Institutions	993,367
18	CHESAPEAKE CORP VA	-0.05185	Manufacturing	337,170
19	ORBCOMM INC	-0.05146	Transportation, Communication, Utilities	281,356
20	DELTA FINANCIAL CORP	-0.05143	Other Financial	169,270
21	BUCKEYE TECHNOLOGIES INC	-0.05142	Manufacturing	300,704
22	AVANEX CORP	-0.05092	Manufacturing	190,784
23	GEORGIA GULF CORP	-0.05073	Manufacturing	1,035,360
24	STRATEX NETWORKS INC	-0.05024	Manufacturing	348,327
25	NET BANK INC	-0.04973	Depository Institutions	347,978
26	STILLWATER MINING CO	-0.04885	Mining	1,090,884
27	FIRST AVENUE NETWORKS INC	-0.04871	Transportation, Communication, Utilities	305,909
28	ASIAINFO HOLDINGS INC	-0.04826	Services	185,964
29	FRANKLIN BANK CORP	-0.04822	Services	424,746
30	WHEELING PITTSBURGH CORP	-0.04815	Manufacturing	131,386
31	CHAMPION ENTERPRISES INC	-0.04795	Manufacturing	1,020,714
32	TOREADOR RESOURCES CORP	-0.04787	Mining	332,036
33	FREEPORT MCMORAN COPPER & GOI	-0.04764	Mining	10,448,800
34	COUNTRYWIDE FINANCIAL CORP	-0.04758	Other Financial	20,904,122
35	REVLON INC	-0.04756	Manufacturing	1,058,697
36	TIENS BIOTECH GROUP USA INC	-0.04733	Services	271,069
37	NASTECH PHARMACEUTICAL CO INC	-0.04732	Services	316,853
38	GRAFTECH INTERNATIONAL LTD	-0.04687	Manufacturing	613,056
39	MERITAGE HOMES CORP	-0.04668	Construction	1,737,800
40	A Z Z INC	-0.04662	Manufacturing	101,665
41	AIRSPAN NETWORKS INC	-0.04646	Transportation, Communication, Utilities	238,008
42	P M I GROUP INC	-0.0463	Insurance	3,709,202
43	ASYST TECHNOLOGIES INC	-0.04624	Manufacturing	280,006
44	CENTURY ALUMINUM CO	-0.04621	Manufacturing	890,964
45	AMERICREDIT CORP	-0.04612	Other Financial	3,536,047
46	SUN HYDRAULICS CORP	-0.04591	Manufacturing	214,993
47	U S E C INC	-0.04588	Mining	1,107,174
48	INDYMAC BANCORP INC	-0.04573	Depository Institutions	2,545,894
49	NEUROGEN CORP	-0.0456	Manufacturing	240,242
50	IGATE CORP	-0.04551	Services	275,444

Table 3: Approximate Contribution CoVaR Test Statistic Critical Values Based on 25,000 Monte Carlo Replications

Stock Correlation	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Test 10% Critical value	1076.89	251.109	104.364	66.117	46.98	35.83	27.223	21.048	16.015	11.443
Test 5% Critical Value	2207.78	381.52	141.19	87.108	61.81	46.9	35.594	28.117	21.466	15.597
Test 1% Critical Value	10434.53	1150.42	219.096	129.69	90.32	69.54	53.372	42.148	32.845	23.257

Notes: Critical values from simulation of the contribution CoVaR or the conditional market return ΔCoVaR

Table 4: Approximate Exposure CoVaR Test Statistic Critical Values Based on 25,000 Monte Carlo Replications

Stock Correlation	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Test 10% Critical value	1103.11	247.255	103.813	65.835	46.58	35.389	27.129	21.362	15.983	11.358
Test 5% Critical Value	2197.08	383.231	141.473	86.272	61.747	46.928	35.69	28.24	21.338	15.55
Test 1% Critical Value	10825.26	1079.206	214.002	129.707	91.148	70.218	54.178	42.176	32.175	23.613

Notes: Critical values from simulation of the conditional stock return or the exposure CoVaR

Table 5: Approximate MES Test Statistic Critical Values Based on 25,000 Monte Carlo Replications

Stock Correlation	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Test 10% Critical value	-22.337	-22.139	-21.861	-21.277	-20.554	-19.561	-18.3899	-16.91	-14.9103	-12.515
Test 5% Critical Value	-28.563	-28.399	-27.93	-27.336	-26.412	-25.2	-23.494	-21.559	-19.272	-16.284
Test 1% Critical Value	-40.116	-39.856	-38.941	-37.871	-36.552	-34.744	-32.586	-30.187	-27.251	-22.849

Table 6: Industry Representation in Sample

Financials	
Depository Institutions	380
Insurance	139
Other Financial	101
Broker Dealers	55
Non-financials	
Manufacturing	1,324
Services	626
Transportation, Communication, Utilities	317
Retail Trade	224
Mining	144
Wholesale Trade	110
Construction	42
Public Administration	13

Table 7: Depository Institutions that are Statistically Significant at 5% Level under the CoVaR Test

Num	Institution	Market Cap (\$thous)
1	COMMONWEALTH BANKSHARES INC	112,239
2	C & F FINANCIAL CORP	120,771
3	EXCHANGE NATIONAL BANKSHARES INC	124,358
4	BANKSHARES OF FLORIDA INC	133,859
5	S I FINANCIAL GROUP INC	134,547
6	RIVERVIEW BANCORP INC	134,897
7	CENTER BANCORP INC	145,737
8	E S B FINANCIAL CORP	147,704
9	C F S BANCORP INC	173,472
10	CENTERSTATE BANKS OF FLORIDA INC	181,598
11	INTERVEST BANKSHARES CORP	189,669
12	FOX CHASE BANCORP INC	190,145
13	CITIZENS FIRST BANCORP INC	193,358
14	BANCTRUST FINANCIAL GROUP INC	225,190
15	FARMERS CAPITAL BANK CORP	229,650
16	PENNFED FINANCIAL SERVICES INC	238,323
17	BANK GRANITE CORP	239,905
18	MIDWEST BANC HOLDINGS INC	487,543
19	HANMI FINANCIAL CORP	885,594
20	BANKUNITED FINANCIAL CORP	993,367

Table 8: Insurance Institutions that are Statistically Significant at the 5% Level under the CoVaR Test

Num	Institution	Market Cap (\$thous)
1	NATIONAL ATLANTIC HOLDINGS CORP	117,628
2	AMCOMP INC NEW	140,022
3	PROCENTURY CORP	140,565
4	N Y M A G I C INC	216,678
5	JAMES RIVER GROUP INC	291,605
6	FIRST MERCURY FINANCIAL CORP	309,563
7	AMTRUST FINANCIAL SERVICES INC	467,680
8	CONSECO INC	3,530,782
9	C I G N A CORP	14,125,094
10	METLIFE INC	38,257,634
11	WELLPOINT INC	48,901,632
12	UNITEDHEALTH GROUP INC	84,261,449

Table 9: Retail Trade Companies that are Statistically Significant at the 5% Level under the CoVaR Test

Num	Company Name	Market Cap (\$thous)
1	FAMOUS DAVES OF AMERICA	119,239
2	TWEETER HOME ENTRTNMNT GROUP	136,670
3	CARIBOU COFFEE CO INC	191,727
4	DENNYS CORP	368,839
5	ASBURY AUTOMOTIVE GROUP INC	536,049
6	BUILD A BEAR WORKSHOP INC	593,157
7	CATO CORP NEW	651,641
8	CHRISTOPHER AND BANKS CORP	670,015
9	BUILDERS FIRSTSOURCE INC	723,316
10	TOO INC	918,995
11	CIRCUIT CITY STORES INC	4,150,447
12	CHICOS FAS INC	7,814,544
13	C V S CORP	21,454,065
14	WALGREEN CO	45,943,894

Table 10: Construction Industry Companies that are Statistically Significant at the 5% level under the CoVaR Test

Num	Company	Market Cap (\$thous)
1	LAYNE CHRISTENSEN CO	396,459
2	PULTE HOMES INC	10,659,344

Table 11: Manufacturing Companies that are Statistically Significant at the 5% Level under a CoVaR Test

Num	Company	Market Cap (\$thous)	Num	Company	Market Cap (\$thous)
1	NETWORK EQUIPMENT TECHNOLOGIES	108,077	57	REDDY ICE HOLDINGS INC	460,479
2	SUNESIS PHARMACEUTICALS INC	110,567	58	AFFYMAX INC	484,823
3	GENAERA CORP	110,613	59	MATTSON TECHNOLOGY INC	529,285
4	VASCULAR SOLUTIONS INC	110,840	60	VEECO INSTRUMENTS INC DEL	535,970
5	ZAPATA CORP	111,383	61	ADAPTEC INC	653,426
6	8X8 INC NEW	112,957	62	USANA HEALTH SCIENCES INC	693,916
7	MEDICINOVA INC	112,960	63	LUFKIN INDUSTRIES INC	776,518
8	VIDEO DISPLAY CORP	113,007	64	GATEHOUSE MEDIA INC	779,120
9	OXIGENE INC	115,512	65	PROQUEST CO	841,624
10	CAVALIER HOMES INC	117,486	66	HEELYS INC	881,145
11	IOMEGA CORP	127,037	67	TENNECO INC DE	900,150
12	ROCKY SHOES & BOOTS INC	129,227	68	COHERENT INC	930,669
13	CHELSEA THERAPEUTICS INTL LTD	134,020	69	INTEGRA LIFESCIENCES HLDNGS CORP	969,436
14	F S I INTERNATIONAL INC	136,136	70	KOMAG INC	1,045,095
15	QUANTUM FUEL SYS TECH WORLDWIDE	139,557	71	OMNIVISION TECHNOLOGIES INC	1,109,889
16	TODD SHIPYARDS CORP	141,269	72	TETRA TECHNOLOGIES INC	1,156,865
17	K V H INDUSTRIES INC	143,892	73	WESTERN REFINING INC	1,235,175
18	GREEN PLAINS RENEWABLE ENERGY IN	144,754	74	MUELLER WATER PRODUCTS INC	1,276,515
19	TUMBLEWEED COMMUNICATIONS CORP	149,964	75	SEMTECH CORP	1,365,097
20	TOLLGRADE COMMUNICATIONS INC	150,107	76	ISILON SYSTEMS INC	1,397,388
21	CUISINE SOLUTIONS INC	150,866	77	OIL STATES INTERNATIONAL INC	1,699,791
22	MERIX CORP	153,029	78	CARPENTER TECHNOLOGY CORP	1,806,587
23	N M S COMMUNICATIONS CORP	162,668	79	M S C INDUSTRIAL DIRECT INC	1,931,327
24	AUXILIUM PHARMACEUTICALS	163,165	80	BRIGGS & STRATTON CORP	2,017,626
25	MULTI COLOR CORP	168,706	81	DEL MONTE FOODS CO	2,056,907
26	LIFE SCIENCES RESEARCH INC	173,082	82	IDEX CORP	2,166,488
27	SOMAXON PHARMACEUTICALS INC	179,548	83	A V X CORP NEW	2,493,143
28	ACHILLION PHARMACEUTICALS INC	183,979	84	PROTEIN DESIGN LABS INC	3,187,043
29	PALATIN TECHNOLOGIES INC	187,479	85	PENTAIR INC	3,468,553
30	TRANSWITCH CORP	191,771	86	SMURFIT STONE CONTAINER CORP	3,491,279
31	NOVAVAX INC	194,023	87	OWENS CORNING NEW	3,626,640
32	BARRIER THERAPEUTICS INC	197,105	88	LIZ CLAIBORNE INC	3,780,636
33	RELIV INTERNATIONAL INC	210,737	89	COOPER CAMERON CORP	4,948,689
34	WELLMAN INC	219,017	90	CONSTELLATION BRANDS INC	5,124,188
35	HOME DIAGNOSTICS INC	221,696	91	COMVERSE TECHNOLOGY INC	5,377,373
36	CAVCO INDUSTRIES INC DEL	246,826	92	MOAIC COMPANY	5,721,570
37	ARCTIC CAT INC	260,693	93	U S T INC	6,779,977
38	VOLCANO CORP	280,782	94	CINTAS CORP	6,969,304
39	OSIRIS THERAPEUTICS INC NEW	298,529	95	PARKER HANNIFIN CORP	7,982,404
40	CHEROKEE INC DEL NEW	301,043	96	DOVER CORP	8,408,696
41	DOT HILL SYSTEMS CORP	304,825	97	HERSHEY CO	9,908,104
42	MANNATECH INC	306,150	98	MURPHY OIL CORP	10,341,498
43	DIAMOND FOODS INC	315,320	99	CONAGRA INC	10,648,136
44	EMERGENT BIOSOLUTIONS INC	320,814	100	SUNOCO INC	11,316,071
45	CLAYMONT STEEL HOLDINGS INC	323,935	101	AMERADA HESS CORP	12,432,268
46	PRESSTEK INC	335,623	102	RAYTHEON CO	17,868,920
47	TITAN INTERNATIONAL INC ILL	337,874	103	BAKER HUGHES INC	21,854,087
48	CHART INDUSTRIES INC	388,938	104	GENERAL DYNAMICS CORP	23,149,845
49	LEAPFROG ENTERPRISES INC	390,815	105	LOCKHEED MARTIN CORP	27,711,422
50	NORTHSTAR NEUROSCIENCE INC	401,388	106	CORNING INC	30,560,449
51	MARINE PRODUCTS CORP	403,501	107	VALERO ENERGY CORP NEW	33,630,793
52	AMERICAN WOODMARK CORP	406,883	108	CATERPILLAR INC	39,316,022
53	CIRCOR INTERNATIONAL INC	410,897	109	DU PONT E I DE NEMOURS & CO	39,588,246
54	NEOWARE SYSTEMS INC	428,482	110	AMGEN INC	98,360,641
55	ACCURIDE CORP	438,283	111	INTERNATIONAL BUSINESS MACHS COR	129,600,000
56	RENOVIS INC	448,369	112	INTEL CORP	151,300,000

Table 12: Depository Institutions with MES Tests that are Statistically Significant at the 5 percent level of the test

Num	Depository Institution	market cap (\$thous)	Num	Depository Institution	market cap (\$thous)	Num	Depository Institution	market cap (\$thous)
1	PAMRAPO BANCORP INC	106,486	43	WAUWATOSA HOLDINGS INC	381,919	85	SOUTH FINL GROUP INC	2,057,069
2	FIRST CITIZENS BANC CORP	106,916	44	VIEWPOINT FINANCIAL GROUP	386,577	86	FIRSTMERIT CORP	2,103,969
3	CHICOPEE BANCORP INC	107,568	45	UNION BANKSHARES CORP	398,152	87	CAPITOL FEDERAL FINANCIAL	2,444,592
4	NORTH BAY BANCORP	108,968	46	VIRGINIA COMMERCE BANCORP	414,897	88	WEBSTER FINL CORP WATERBURY CONN	2,544,290
5	COMMONWEALTH BANKSHARES INC	112,239	47	CENTER FINANCIAL CORP	424,455	89	INDYMAC BANCORP INC	2,545,894
6	BRIDGE CAPITAL HOLDINGS	116,650	48	TAYLOR CAPITAL GROUP INC	442,801	90	BANK OF HAWAII CORP	2,689,011
7	AMERICAN RIVER BANKSHARES	124,801	49	MIDWEST BANC HOLDINGS INC	487,543	91	WILMINGTON TRUST CORP	2,691,098
8	HERITAGE OAKS BANCORP	133,988	50	K N B T BANCORP INC	498,778	92	VALLEY NATIONAL BANCORP	2,709,993
9	LEGACY BANCORP INC	138,450	51	1ST SOURCE CORP	540,002	93	CULLEN FROST BANKERS INC	2,948,974
10	NORTHEAST COMMUNITY BANCORP	145,475	52	OCWEN FINANCIAL CORP	546,074	94	B O K FINANCIAL CORP	3,060,955
11	E S B FINANCIAL CORP	147,704	53	TEXAS CAPITAL BANCSHARES IN	594,654	95	ASTORIA FINANCIAL CORP	3,146,958
12	L S B BANCSHARES N C	150,449	54	IRWIN FINANCIAL CORP	615,909	96	CITY NATIONAL CORP	3,622,601
13	FIRST M & F CORP	152,830	55	BANCFIRST CORP	621,689	97	T C F FINANCIAL CORP	3,667,425
14	PARKVALE FINANCIAL CORP	157,189	56	WESBANCO INC	680,385	98	COLONIAL BANCGROUP INC	3,683,356
15	FIRST LONG ISLAND CORP	164,036	57	STERLING BANCSHARES INC	689,077	99	PEOPLES BANK BRIDGEPORT	4,432,080
16	BANK OF MARIN	169,136	58	FIRST FINANCIAL BANCORP OHIC	717,277	100	FIRST HORIZON NATIONAL CORP	4,961,998
17	FIRST SECURITY GROUP INC	169,478	59	PRIVATEBANCORP INC	748,289	101	HUNTINGTON BANCSHARES INC	5,408,586
18	FIRST NATIONAL LINCOLN CORP ME	172,569	60	P F F BANCORP INC	758,839	102	SOVEREIGN BANCORP INC	7,789,616
19	K FED BANCORP	173,255	61	CHEMICAL FINANCIAL CORP	815,068	103	ZIONS BANCORP	8,041,719
20	C F S BANCORP INC	173,472	62	BROOKLINE BANCORP INC	880,651	104	SYNOVUS FINANCIAL CORP	8,582,224
21	INTEGRITY BANCSHARES INC	181,449	63	STERLING FINANCIAL CORP WAS	881,160	105	COMERICA INC	9,519,437
22	OAK HILL FINANCIAL INC	184,820	64	KEARNY FINANCIAL CORP	893,214	106	UNIONBANCAL CORP	10,002,390
23	FOX CHASE BANCORP INC	190,145	65	REPUBLIC BANCORP	902,711	107	MARSHALL & ILSLEY CORP	10,260,955
24	BANC CORP THE	230,369	66	S & T BANCORP INC	984,637	108	NORTHERN TRUST CORP	11,410,328
25	BANCORP INC	231,863	67	BANKUNITED FINANCIAL CORP	993,367	109	M & T BANK CORP	12,472,390
26	GREENE COUNTY BANCSHARES INC	268,370	68	UNITED COMMUNITY BANKS INC	1,068,934	110	KEYCORP NEW	13,730,188
27	VINEYARD NATIONAL BANCORP	286,611	69	BOSTON PRIVATE FINL HLDS INC	1,076,364	111	MELLON FINANCIAL CORP	14,713,818
28	FIRST REGIONAL BANCORP	287,232	70	PROVIDENT BANKSHARES CORP	1,144,093	112	REGIONS FINANCIAL CORP NEW	15,793,800
29	BERKSHIRE HILLS BANCORP INC	294,801	71	PROVIDENT FINANCIAL SVCS INC	1,298,789	113	P N C FINANCIAL SERVICES GRP INC	18,574,457
30	FLUSHING FINANCIAL CORP	297,635	72	M A F BANCORP INC	1,338,477	114	STATE STREET CORP	18,684,027
31	PREFERRED BANK LOS ANGELES	299,467	73	UNITED BANKSHARES INC	1,494,645	115	NATIONAL CITY CORP	21,061,440
32	PEOPLES BANCORP INC	301,685	74	CORUS BANKSHARES INC	1,576,646	116	B B & T CORP	22,944,545
33	CLIFTON SAVINGS BANCORP INC	307,333	75	NEWALLIANCE BANCSHARES INC	1,628,992	117	BANK NEW YORK INC	25,029,805
34	CAPITAL CORP OF THE WEST	342,736	76	S V B FINANCIAL GROUP	1,634,045	118	SUNTRUST BANKS INC	26,754,590
35	NET BANK INC	347,978	77	FIRST NIAGARA FINL GROUP INC	1,666,174	119	WASHINGTON MUTUAL INC	43,621,980
36	REPUBLIC BANCORP INC KY	351,955	78	U C B H HOLDINGS INC	1,704,909	120	U S BANCORP DEL	54,998,958
37	FIRST COMMUNITY BANCSHARES INC	351,963	79	PACIFIC CAPITAL BANCORP NEW	1,730,010	121	WACHOVIA CORP 2ND NEW	84,058,209
38	FIRST FINANCIAL CORP IN	363,238	80	WESTAMERICA BANCORPORATIC	1,735,656	122	WELLS FARGO & CO NEW	106,700,000
39	BANKFINACIAL CORP	365,277	81	BANCORPSOUTH INC	1,772,951	123	JPMORGAN CHASE & CO	140,600,000
40	UNITED COMMUNITY FINL CORP OHI	371,191	82	WHITNEY HOLDING CORP	1,777,320	124	BANK OF AMERICA CORP	189,100,000
41	INTEGRA BANK CORP	375,323	83	CATHAY GENERAL BANCORP	1,854,558	125	CITIGROUP INC	249,400,000
42	FIRST PLACE FINANCIAL CORP NM	375,438	84	INTERNATIONAL BANCSHARES C	1,864,073			

Table 13: Insurance Companies with MES Test Statistics that are Statistically Significant at the 5 percent level

Num	Institution	Market Cap (\$thous)
1	AMERISAFE INC	170,755
2	N Y M A G I C INC	216,678
3	CITIZENS INC	219,880
4	INDEPENDENCE HOLDING CO NEW	282,539
5	F P I C INSURANCE GROUP INC	357,729
6	AMERICAN PHYSICIANS CAPITAL INC	385,151
7	TOWER GROUP INC	429,684
8	AMTRUST FINANCIAL SERVICES INC	467,680
9	EHEALTH INC	479,732
10	FIRST ACCEPTANCE CORP	507,768
11	BRISTOL WEST HOLDINGS INC	618,236
12	SAFETY INSURANCE GROUP INC	629,310
13	TRIAD GUARANTY INC	651,533
14	AMERICAN EQUITY INVT LIFE HLDG C	696,985
15	FIDELITY NATIONAL TITLE GP INC	738,720
16	HARLEYSVILLE GROUP INC	812,695
17	F B L FINANCIAL GROUP INC	918,733
18	MUNICIPAL MORTGAGE & EQUITY LLC	997,230
19	HEALTHSPRING INC	1,259,234
20	R L I CORP	1,305,600
21	DELPHI FINANCIAL GROUP INC	1,335,929
22	PHOENIX COS INC	1,338,057
23	SELECTIVE INSURANCE GROUP INC	1,570,883
24	ODYSSEY RE HOLDINGS CORP	1,720,536
25	FREMONT GENERAL CORP	1,833,178
26	PHILADELPHIA CONSOLIDATED HLG CO	2,225,780
27	HANOVER INSURANCE GROUP INC	2,307,811
28	NATIONWIDE FINANCIAL SERVICES IN	2,513,570
29	STANCORP FINANCIAL GROUP INC	2,748,548
30	AMERICAN FINANCIAL GROUP INC NEW	2,967,992
31	GALLAGHER ARTHUR J & CO	2,983,568
32	REINSURANCE GROUP OF AMERICA INC	2,991,782
33	UNITRIN INC	3,169,490
34	ERIE INDEMNITY CO	3,248,367
35	H C C INSURANCE HOLDINGS INC	3,285,622
36	CONSECO INC	3,530,782
37	P M I GROUP INC	3,709,202
38	TRANSATLANTIC HOLDINGS INC	4,431,204
39	RADIAN GROUP INC	4,804,772
40	OLD REPUBLIC INTERNATIONAL CORP	4,949,913
41	ASSURANT INC	5,768,631
42	TORCHMARK CORP	5,790,812
43	M G I C INVESTMENT CORP WIS	6,100,752
44	BERKLEY W R CORP	6,188,195
45	SAFECO CORP	7,137,900
46	CINCINNATI FINANCIAL CORP	7,812,600
47	AMBAC FINANCIAL GROUP INC	8,216,235
48	LINCOLN NATIONAL CORP IN	9,273,430
49	AON CORP	11,920,522
50	GENWORTH FINANCIAL INC	13,330,244
51	PRINCIPAL FINANCIAL GROUP INC	13,371,607
52	MARSH & MCLENNAN COS INC	17,365,036
53	LOEWS CORP	17,967,308
54	CHUBB CORP	19,550,221
55	A F L A C INC	23,302,184
56	HARTFORD FINANCIAL SVCS GRP INC	26,451,374
57	ST PAUL TRAVELERS COS INC	31,845,777
58	PRUDENTIAL FINANCIAL INC	38,223,451
59	METLIFE INC	38,257,634
60	AMERICAN INTERNATIONAL GROUP INC	180,700,000

Table 14: Retail Trade Companies with MES Tests that are Statistically Significant at the 5 percent level

Num	Company	Market Cap (\$thous)
1	BUCA INC	111,562
2	FAMOUS DAVES OF AMERICA	119,239
3	BLAIR CORP	155,787
4	1 800 FLOWERS COM INC	179,466
5	DELIA S INC NEW	186,850
6	INGLES MARKETS INC	190,039
7	CARIBOU COFFEE CO INC	191,727
8	EDDIE BAUER HOLDINGS INC	283,708
9	MORTONS RESTAURANT GROUP INC NEW	288,172
10	MIDAS INC	305,187
11	O CHARLEYS INC	360,682
12	DENNYS CORP	368,839
13	A F C ENTERPRISES INC	457,230
14	VALUEVISION MEDIA INC	463,233
15	CHARLOTTE RUSSE HOLDING INC	477,099
16	FREDS INC	618,979
17	CATO CORP NEW	651,641
18	99 CENTS ONLY STORES	725,427
19	WINN DIXIE STORES INC	769,760
20	C K E RESTAURANTS INC	797,359
21	GENESCO INC	867,192
22	TOO INC	918,995
23	CONNS INC	921,239
24	JACK IN THE BOX INC	1,213,338
25	LONGS DRUG STORES INC	1,407,860
26	BORDERS GROUP INC	1,432,927
27	AEROPOSTALE INC	1,480,657
28	RUBY TUESDAY INC	1,625,200
29	C B R L GROUP INC	1,641,171
30	PACIFIC SUNWEAR OF CA INC	1,789,867
31	DILLARDS INC	1,902,536
32	B J S WHOLESALE CLUB INC	1,961,531
33	ANNTAYLOR STORES CORP	2,490,599
34	DOLLAR TREE STORES INC	2,574,517
35	CLAIRES STORES INC	2,752,188
36	BARNES & NOBLE INC	2,763,012
37	ARAMARK CORP	3,227,146
38	FOOT LOCKER INC	3,656,392
39	FAMILY DOLLAR STORES INC	3,861,441
40	ALBERTO CULVER CO	4,253,680
41	ROSS STORES INC	4,259,968
42	ADVANCE AUTO PARTS INC	4,707,863
43	TIFFANY & CO NEW	5,516,183
44	WENDYS INTERNATIONAL INC	6,436,264
45	AUTOZONE INC	7,117,104
46	LIMITED BRANDS INC	8,925,932
47	T J X COMPANIES INC NEW	10,664,973
48	YUM BRANDS INC	13,233,149
49	KROGER COMPANY	13,747,903
50	GAP INC	15,401,076
51	FEDERATED DEPT STORES INC DEL	18,570,576
52	SEARS HOLDINGS CORP	18,847,305
53	MCDONALDS CORP	42,187,334
54	HOME DEPOT INC	87,605,558
55	WAL MART STORES INC	192,500,000

**Table 15: Construction Companies with MES Test
Statistics Statitically Significant at the 5 percent level**

Num	Company	Market Cap (\$thous)
1	MODTECH HOLDINGS INC	152,534
2	MATRIX SERVICE CO	193,248
3	INFRASOURCE SERVICES INC	518,478
4	PIKE ELECTRIC CORP	532,060
5	PERINI CORP	656,443
6	EMCOR GROUP INC	1,105,102
7	K B R INC	3,391,940

Table 16a: Manufacturing Companies with MES Tests that are Statistically Significant at the 5 percent level

Num	Company	Market Cap (\$thous)	Num	Company	Market Cap (\$thous)
1	A Z Z INC	101,665	72	TRUE RELIGION APPAREL INC	348,666
2	ENTREMED INC	101,703	73	QUIDEL CORP	351,291
3	NEUROBIOLOGICAL TECHNOLOGIE	106,081	74	MEASUREMENT SPECIALTIES INC	352,206
4	GENVEC INC	106,974	75	SUPERIOR ESSEX INC	353,174
5	NETWORK EQUIPMENT TECHNOLO	108,077	76	SCHWEITZER MAUDUIT INTL INC	372,484
6	NOBILITY HOMES INC	110,608	77	TRONOX INC	388,884
7	VASCULAR SOLUTIONS INC	110,840	78	LEAPFROG ENTERPRISES INC	390,815
8	PENFORD CORP	112,472	79	ALBANY MOLECULAR RESEARCH IN	394,174
9	ALLOS THERAPEUTICS	126,682	80	COMMERCIAL VEHICLE GROUP INC	395,642
10	IOMEGA CORP	127,037	81	MONACO COACH CORP	396,064
11	T V I CORP NEW	129,575	82	NEENAH PAPER INC	412,773
12	SPARTAN MOTORS INC	130,667	83	AFTERMARKET TECHNOLOGY CORI	435,320
13	BIOVERIS CORP	130,742	84	TASER INTERNATIONAL INC	437,289
14	WHEELING PITTSBURGH CORP	131,386	85	ACCURIDE CORP	438,283
15	JOHNSON OUTDOORS INC	132,127	86	WD 40 CO	443,560
16	POPE & TALBOT INC	132,429	87	AMERICAN RAILCAR INDUSTRIES IN	457,562
17	AMPCO PITTSBURGH CORP	136,347	88	PREMIUM STANDARD FARMS INC	458,490
18	PARK OHIO HOLDINGS CORP	148,095	89	SIGMATEL INC	474,822
19	STONERIDGE INC	148,597	90	BOWNE & CO INC	493,503
20	CHOLESTECH CORP	149,264	91	ROCK TENN CO	509,838
21	HARDINGE INC	149,772	92	O M GROUP INC	542,671
22	FOSTER L B CO	149,793	93	VITAL SIGNS INC	549,777
23	TOLLGRADE COMMUNICATIONS IN	150,107	94	CUBIC CORP	561,120
24	IMMUNOMEDICS INC	150,227	95	JOURNAL COMMUNICATIONS INC	574,192
25	CHINA AUTOMOTIVE SYSTEMS INC	151,027	96	MERIDIAN BIOSCIENCE INC	574,469
26	FLOTEK INDUSTRIES INC	155,920	97	ENPRO INDUSTRIES INC	575,210
27	IMMERSION CORP	156,878	98	WABASH NATIONAL CORP	591,534
28	NUTRACEUTICAL INTERNATIONAL	157,328	99	EXTREME NETWORKS INC	593,989
29	UNIFI INC	159,042	100	POLYONE CORP	597,591
30	OMEGA PROTEIN CORP	164,401	101	WAUSAU PAPER CORP	605,246
31	RITA MEDICAL SYSTEMS INC	165,583	102	CASCADE CORP	606,840
32	CARRIER ACCESS CORP	167,226	103	GRAFTECH INTERNATIONAL LTD	613,056
33	ELLIS PERRY INTERNATIONAL INC	183,821	104	GLATFELTER P H CO	621,373
34	AXSYS TECHNOLOGIES INC	184,328	105	RYERSON INC	648,390
35	STURM RUGER & CO INC	188,915	106	KELLWOOD COMPANY	655,448
36	AVANEX CORP	190,784	107	SCHULMAN A INC	670,248
37	POWELL INDUSTRIES INC	198,754	108	ARGON ST INC	677,506
38	KEITHLEY INSTRUMENTS INC	202,414	109	HOLLINGER INTERNATIONAL INC	683,454
39	OCTEL CORP	207,941	110	COMTECH TELECOMMUNICATIONS	697,823
40	LIFECORE BIOMEDICAL INC	210,684	111	SCHNITZER STEEL INDUSTRIES INC	698,633
41	MEDICAL ACTION INDS INC	212,753	112	NEWPARK RESOURCES INC	702,096
42	SUN HYDRAULICS CORP	214,993	113	GRIFFON CORP	718,907
43	DUCOMMUN INC DE	216,295	114	CENVEO INC	725,102
44	ADVENTRX PHARMACEUTICALS INI	221,569	115	CREDENCE SYSTEMS CORP	732,232
45	HOME DIAGNOSTICS INC	221,696	116	GREIF INC	733,407
46	AAON INC	222,536	117	BARNES GROUP INC	771,224
47	CALGON CARBON CORP	224,079	118	GATEHOUSE MEDIA INC	779,120
48	STRATAGENE CORP	229,663	119	BROWN SHOE CO INC NEW	780,976
49	RUSS BERRIE & CO	237,394	120	NACCO INDUSTRIES INC	800,426
50	HOOKE FURNITURE CORP	240,032	121	VECTOR GROUP LTD	807,431
51	HERLEY INDUSTRIES INC	249,949	122	TRIARC COMPANIES INC	810,692
52	DARLING INTERNATIONAL INC	253,237	123	C F INDUSTRIES HOLDINGS INC	841,928
53	APPLIED SIGNAL TECHNOLOGY	262,776	124	BALDOR ELECTRIC CO	862,634
54	BADGER METER INC	270,843	125	HEELYS INC	881,145
55	R B C BEARINGS INC	271,584	126	A K STEEL HOLDING CORP	890,535
56	AETERNA ZENTARIS INC	276,297	127	KNOLL INC	910,805
57	CHINA PRECISION STEEL INC	290,057	128	N C I BUILDING SYSTEMS INC	915,406
58	L T X CORP	292,334	129	TEKELEC	928,380
59	EXCEL TECHNOLOGY INC	295,496	130	ALON U S A ENERGY INC	939,684
60	NATIONAL PRESTO INDS INC	299,023	131	FULLER H B CO	951,988
61	BUCKEYE TECHNOLOGIES INC	300,704	132	COOPER TIRE & RUBBER CO	964,501
62	DOT HILL SYSTEMS CORP	304,825	133	GENCORP INC	967,345
63	COLE KENNETH PRODUCTIONS INC	308,569	134	UTSTARCOM INC	971,915
64	M & F WORLDWIDE CORP	315,322	135	BIOSITE INC	980,439
65	C S S INDUSTRIES INC	324,035	136	MUELLER INDUSTRIES INC	1,007,801
66	I FLOW CORP	327,894	137	M K S INSTRUMENTS INC	1,009,064
67	ALTRA HOLDINGS INC	329,928	138	SONUS NETWORKS INC	1,025,174
68	CHESAPEAKE CORP VA	337,170	139	GEORGIA GULF CORP	1,035,360
69	TITAN INTERNATIONAL INC ILL	337,874	140	REVLON INC	1,058,697
70	VALUE LINE INC	348,272	141	WINNEBAGO INDUSTRIES INC	1,079,254
71	STRATEX NETWORKS INC	348,327	142	N B T Y INC	1,081,152

Table 16b: Manufacturing Companies with MES Tests that are Statistically Significant at the 5 percent level

Num	Company	Market Cap (\$thous)	Num	Company	Market Cap (\$thous)
143	CROCS INC	1,092,666	214	TEMPLE INLAND INC	4,994,369
144	TEMPUR PEDIC INTERNATIONAL IN	1,152,029	215	MEADWEST VACO CORP	5,061,003
145	MULTI FINELINE ELECTRONIX INC	1,174,184	216	COMVERSE TECHNOLOGY INC	5,377,373
146	TESSERA TECHNOLOGIES	1,202,130	217	MOLSON COORS BREWING CO	5,519,126
147	WARNACO GROUP INC	1,213,457	218	WHIRLPOOL CORP	5,577,414
148	BANTA CORP	1,219,332	219	UNITED STATES STEEL CORP NEW	5,605,705
149	WOLVERINE WORLD WIDE INC	1,270,978	220	SCRIPPS E W CO OHIO	6,145,611
150	A C C O BRANDS CORP	1,271,597	221	N C R CORP NEW	6,240,564
151	LANCASTER COLONY CORP	1,277,196	222	NEWELL RUBBERMAID INC	6,570,675
152	VIOPHARMA	1,310,944	223	U S T INC	6,779,977
153	AMERICAN GREETINGS CORP	1,352,297	224	BARD C R INC	6,869,903
154	TUPPERWARE BRANDS CORP	1,370,765	225	BLACK & DECKER CORP	6,891,543
155	SILGAN HOLDINGS INC	1,377,724	226	PEPSI BOTTLING GROUP INC	6,912,746
156	OLIN CORP	1,431,591	227	CINTAS CORP	6,969,304
157	D R S TECHNOLOGIES INC	1,435,424	228	PRECISION CASTPARTS CORP	7,025,120
158	LEE ENTERPRISES INC	1,440,793	229	DONNELLEY R R & SONS CO	7,322,690
159	ROCKWOOD HOLDINGS INC	1,445,331	230	JABIL CIRCUIT INC	7,609,317
160	DELUXE CORP	1,562,297	231	ROCKWELL COLLINS INC	8,133,999
161	MARVEL ENTERTAINMENT INC	1,578,639	232	CLOROX CO	8,612,620
162	FLOWERS FOODS INC	1,737,750	233	L 3 COMMUNICATIONS HLDGS INC	9,053,374
163	CARPENTER TECHNOLOGY CORP	1,806,587	234	ECOLAB INC	9,140,057
164	WILEY JOHN & SONS INC	1,810,917	235	TRIBUNE COMPANY NEW	9,483,967
165	LEAR CORP	1,901,554	236	I T T INDUSTRIES INC IND	9,670,159
166	ALBEMARLE CORP	1,910,062	237	P P G INDUSTRIES INC	9,687,566
167	TORO COMPANY	1,927,351	238	TEXTRON INC	10,258,830
168	JARDEN CORP	2,038,710	239	CONAGRA INC	10,648,136
169	R P M INTERNATIONAL INC	2,047,377	240	GENERAL MOTORS CORP	10,688,082
170	F M C CORP	2,053,689	241	HEINZ H J CO	11,321,853
171	DEL MONTE FOODS CO	2,056,907	242	FORTUNE BRANDS INC	11,455,181
172	LENNOX INTERNATIONAL INC	2,071,318	243	PACCAR INC	11,882,115
173	MEREDITH CORP	2,084,821	244	CAMPBELL SOUP CO	12,407,760
174	POLARIS INDUSTRIES INC	2,140,063	245	AVON PRODUCTS INC	12,967,910
175	ARMSTRONG WORLD INDS INC NEV	2,163,240	246	MASCO CORP	13,226,798
176	CRANE CO	2,163,785	247	FORD MOTOR CO DEL	13,990,331
177	IDEX CORP	2,166,488	248	KRAFT FOODS INC	14,067,523
178	SNAP ON INC	2,232,043	249	XEROX CORP	14,319,594
179	CYTEC INDUSTRIES INC	2,232,160	250	JOHNSON CONTROLS INC	14,339,165
180	METTLER TOLEDO INTERNATIONAL	2,311,456	251	SARA LEE CORP	14,393,246
181	CABOT CORP	2,334,846	252	ALLERGAN INC	14,649,906
182	HUBBELL INC	2,356,903	253	GANNETT INC	14,880,438
183	PACKAGING CORP AMERICA	2,473,505	254	WEYERHAEUSER CO	16,209,380
184	SMUCKER J M CO	2,648,967	255	INTERNATIONAL PAPER CO	16,426,812
185	TELEFLEX INC	2,662,207	256	NIKE INC	16,737,043
186	SONOCO PRODUCTS CO	2,898,968	257	AGILENT TECHNOLOGIES INC	17,185,500
187	LOUISIANA PACIFIC CORP	2,920,420	258	GENERAL MILLS INC	17,614,535
188	LUBRIZOL CORP	2,950,780	259	RAYTHEON CO	17,868,920
189	HILLENBRAND INDS INC	3,033,793	260	MCGRAW HILL COS INC	19,427,318
190	PERKINELMER INC	3,137,820	261	NORTHROP GRUMMAN CORP	21,186,659
191	PACTIV CORP	3,146,517	262	GENERAL DYNAMICS CORP	23,149,845
192	GOODYEAR TIRE & RUBBER CO	3,150,558	263	BAXTER INTERNATIONAL INC	23,922,140
193	SCOTTS MIRACLE GRO CO	3,171,073	264	ALCOA INC	26,019,368
194	PEPSIAMERICAS INC NEW	3,182,566	265	LOCKHEED MARTIN CORP	27,711,422
195	SYMBOL TECHNOLOGIES INC	3,224,952	266	COLGATE PALMOLIVE CO	28,446,400
196	OSHKOSH TRUCK CORP	3,288,812	267	EMERSON ELECTRIC CO	30,892,328
197	CROWN HOLDINGS INC	3,298,578	268	HONEYWELL INTERNATIONAL INC	31,569,751
198	SMITHFIELD FOODS INC	3,340,627	269	E M C CORP MA	32,704,667
199	SMURFIT STONE CONTAINER CORP	3,491,279	270	ANHEUSER BUSCH COS INC	33,902,548
200	BORGWARNER INC	3,520,876	271	DU PONT E I DE NEMOURS & CO	39,588,246
201	JONES APPAREL GROUP INC	3,563,132	272	DOW CHEMICAL CO	42,397,810
202	OWENS CORNING NEW	3,626,640	273	BOEING CO	56,863,749
203	WATSON PHARMACEUTICALS INC	3,650,246	274	UNITED TECHNOLOGIES CORP	57,584,453
204	LIZ CLAIBORNE INC	3,780,636	275	WYETH	62,415,044
205	STANLEY WORKS	4,027,542	276	HEWLETT PACKARD CO	81,639,307
206	IDEARC INC	4,117,200	277	CONOCOPHILLIPS	86,147,480
207	BALL CORP	4,183,529	278	COCA COLA CO	97,308,057
208	TYSON FOODS INC	4,225,508	279	PEPSICO INC	99,261,357
209	SIGMA ALDRICH CORP	4,274,223	280	CISCO SYSTEMS INC	107,200,000
210	MYLAN LABS INC	4,306,220	281	CHEVRON CORP NEW	132,600,000
211	ASHLAND INC NEW	4,314,959	282	ALTRIA GROUP INC	156,100,000
212	THERMO ELECTRON CORP	4,912,870	283	EXXON MOBIL CORP	363,800,000
213	GOODRICH CORP	4,927,703	284	GENERAL ELECTRIC CO	373,700,000

Table 17: MES and CoVaR Test Results Comparison for the 25 Largest Depository Institutions Measured by Market Capitalization at the Beginning of the Sample

Market Cap Rank	Institution	MES			CoVaR			Market Cap (\$thous)
		MES	MES Statistically Sig at 10%	MES Statistically Sig at 5%	CoVaR	CoVaR Statistically Sig at 10%	CoVaR Statistically Sig at 5%	
1	CITIGROUP INC	-0.027	yes	yes	-0.013	no	no	249,400,000
2	BANK OF AMERICA CORP	-0.021	yes	yes	-0.015	yes	no	189,100,000
3	JPMORGAN CHASE & CO	-0.026	yes	yes	-0.014	no	no	140,600,000
4	WELLS FARGO & CO NEW	-0.023	yes	yes	-0.009	no	no	106,700,000
5	WACHOVIA CORP 2ND NEW	-0.023	yes	yes	-0.012	no	no	84,058,209
6	U S BANCORP DEL	-0.018	yes	yes	-0.006	no	no	54,998,958
7	WASHINGTON MUTUAL INC	-0.042	yes	yes	-0.010	no	no	43,621,980
8	SUNTRUST BANKS INC	-0.023	yes	yes	-0.010	no	no	26,754,590
9	BANK NEW YORK INC	-0.027	yes	yes	-0.009	no	no	25,029,805
10	B B & T CORP	-0.024	yes	yes	-0.008	no	no	22,944,545
11	NATIONAL CITY CORP	-0.027	yes	yes	-0.010	no	no	21,061,440
12	STATE STREET CORP	-0.029	yes	yes	-0.008	no	no	18,684,027
13	P N C FINANCIAL SERVICES GRP INC	-0.021	yes	yes	-0.008	no	no	18,574,457
14	REGIONS FINANCIAL CORP NEW	-0.026	yes	yes	-0.009	no	no	15,793,800
15	MELLON FINANCIAL CORP	-0.021	yes	yes	-0.007	no	no	14,713,818
16	KEYCORP NEW	-0.026	yes	yes	-0.012	no	no	13,730,188
17	M & T BANK CORP	-0.025	yes	yes	-0.009	no	no	12,472,390
18	NORTHERN TRUST CORP	-0.025	yes	yes	-0.011	no	no	11,410,328
19	MARSHALL & ILSLEY CORP	-0.026	yes	yes	-0.011	no	no	10,260,955
20	UNIONBANCAL CORP	-0.023	yes	yes	-0.013	no	no	10,002,390
21	COMERICA INC	-0.024	yes	yes	-0.008	no	no	9,519,437
22	SYNOVUS FINANCIAL CORP	-0.024	yes	yes	-0.008	no	no	8,582,224
23	ZIONS BANCORP	-0.027	yes	yes	-0.011	no	no	8,041,719
24	SOVEREIGN BANCORP INC	-0.032	yes	yes	-0.007	no	no	7,789,616
25	HUDSON CITY BANCORP INC	-0.015	yes	no	-0.011	no	no	7,208,209









