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How diversified are international portfolios?

Correlations between international equity markets increase with the level of shock experienced by the market, reducing the benefits of international diversification.

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Portfolio allocation strategies typically employ, as a basic input, the variance-covariance (risk) matrix of returns from candidate assets in the portfolio. This approach is static as it assumes that this matrix does not change over time or, at least, is valid for some trading horizon. The objective here is to study the time and state variation in the risk matrix, and analyze how this variation affects an investor's optimal portfolio.

The analysis of the effect of variation in the correlation between international asset returns is important because the absolute amount of investment in international assets is extremely large. For example, U.S. pension fund assets in non-U.S. equities exceed $140 billion, compared to $80 billion in 1988;[1] international equity flows are in excess of $1.5 trillion per year; and, cross-border equity flows exceed 20% of total world equity trading.[2] The riskiness of foreign exchange positions is illustrated by the fact that in recent times the volatility of the U.S. Dollar/Deutsche Mark rate has exceeded that of the S&P 500, and the volatility of monthly foreign exchange rates is four times that of interest rates.

Recent research[3] finds that correlation between returns on international equities have been increasing over time, and also tend to be higher in periods of high market volatility. The purpose here is to extend this work in three directions: (i) to show, using a simple framework, that correlations between international equity returns vary with size of the shock in the economy; (ii) to characterize the optimal portfolio allocation when correlations increase with aggregate market shocks; and (iii) to demonstrate that the positive relation between shock size and the correlation of returns is also present in U.S. equity and bond markets.

Correlation Between Returns

The relation between the correlations of asset returns and the shock to the market return is positive.

The analysis was carried out from the perspective of a U.S. investor. The data on international equities consists of monthly returns between August 1976 to July 1992 on the value-weighted stock indices reported by the New York Federal Reserve, for six countries: Canada (CA), Germany (GE), Italy (IT), Japan (JA), Switzerland (SZ), and the United Kingdom (UK), and an aggregate measure, the Morgan Stanley World Index (MSCI). For comparison purposes, two portfolios of only U.S. assets were analyzed: the first portfolio was allocated across only U.S. equities (decile size-based portfolios), while the second portfolio consists of investment in the S&P 500 index, a small-stock index and a government-bond index. The data for these portfolios, covering the period January 1971 to December 1994, was obtained from the CRSP tapes.

The data on international equity indices used was in U.S. dollar terms where the foreign indices were converted into U.S. dollars at the then prevailing exchange rate. To obtain the return series, log differences of the data were taken. Consequently, the returns are monthly returns from investing a dollar in an overseas equity index and converting the return back into U.S. dollars at the end of the month. Thus, the returns are sensitive to changes in the index in local currency and to changes in exchange rates.

Table 1 (page 8) indicates that the major markets in the world demonstrate a reasonable degree of correlation with each other. The objective is to examine whether this level of correlation increases significantly with the size of the shock to the economy, where the shock is defined as the change over the last time interval in the level of the measure of the shock.

Shocking The System

The shock to the economy is measured in two ways. The first measure is based on the absolute value of the sum of the shocks in the prices of the securities in the portfolio being considered. Thus, this measure is limited to the markets for the assets being considered in the portfolio. To capture more than just the shock in a few asset markets, a broader measure is the absolute change in the Morgan Stanley Capital

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Index (MSCI).

One simple and informal approach to study if the correlations between returns increase with the size of the shock is to sort the sample by the size of the shock and divide it into two parts with an equal number of observations in each of the two subsamples. The correlation matrix of returns was then computed for each subsample. The correlations in the high-shock subsample were examined to determine if they were higher than those for the low-shock subsample. In the case where the measure of shock is the MSCI, this analysis was repeated by sorting the data on the basis of the absolute change in the MSCI index.

From Table 2 (page 9) it can be seen that splitting the sample on the basis of the size of the absolute shock to the portfolio returns results in a clear dichotomy of correlation levels between the low-shock and high-shock states. In fact, the differences between the correlation levels in the high shock state and those in the low shock state (the third number in each cell) are all positive. The results on the correlations between returns on a portfolio diversified over only U.S. assets are similar.

Table 1

Good correlations

The correlations between the monthly returns, translated into U.S. dollars, on seven country equity indices are reasonably good.

Country	Italy	Canada	Germany	Japan	Switzerland	UK	US
Italy	1.00						
Canada	0.32	1.00					
Germany	0.35	0.38	1.00				
Japan	0.40	0.36	0.38	1.00			
Switzerland	0.39	0.59	0.69	0.43	1.00		
UK	0.42	0.51	0.47	0.40	0.59	1.00	
US	0.24	0.72	0.39	0.35	0.55	0.50	1.00

190 observations between August 1976 and July 1992.

Wider Shocks

The results for the case where the data on international equities is split on the basis of the absolute change in the MSCI are reported in Table 3. As would be expected with a measure of the shock that is more general, the relation between the shocks to this aggregate measure and the correlation between the returns on a small subset of securities is weaker. However, even these results indicate that the correlations in the high-shock state are typically larger than those in the low-shock state.

While the results in Tables 2 and 3 are based on an informal analysis of the data, this evidence on the relation between the size of the absolute shock to returns and the correlations between them is supported when a formal econometric approach, the Generalized Method of Moments, is used to analyze the data.[4]

Table 3

More general system shocks

Even when more widespread shocks are examined (here the shock to the Morgan Stnaley Capital Index) the correlations in the high-shock state are larger than those in the low-shock state.

Country	IT	CA	GE	JA	SZ	UK	US
IT: low	1.00						
IT: high	1.00						
IT: high-low	0.00						
CA	0.26	1.00					
CA	0.38	1.00					
CA	0.12	0.00					
GE	0.07	0.32	1.00				
GE	0.53	045	1.00				
GE	0.46	0.13	0.00				
JA	0.31	0.40	0.35	1.00			
JA	0.49	0.38	0.39	1.00			
JA	0.17	-0.02	0.06	0.00			
SZ	0.16	0.49	0.55	0.37	1.00		
SZ	0.56	0.70	0.74	0.45	1.00		
SZ	0.40	0.21	0.19	0.08	0.00		
UK	0.39	0.29	0.43	0.45	0.43	1.00	
UK	0.46	0.75	0.53	0.41	0.72	1.00	
UK	0.07	0.46	0.10	-0.04	0.29	0.00	
US	0.12	0.72	0.30	0.36	0.39	0.28	1.00
US	0.36	0.73	0.45	0.38	0.64	0.70	1.00
US	0.24	0.01	0.15	0.02	0.25	0.42	0.00

Data is from August 1976 to July 1992.

Portfolio Impact

The implications for portfolio choice, of the relation between shocks to returns and the correlations between asset returns, were examined by considering the portfolio decisions of an investor who is optimizing over a single period and who uses the results in Table 2 to calibrate the portfolio choice model.[5]

The problem of the investor is to choose a vector of portfolio weights to maximize expected utility, subject to the constraint that the portfolio weights sum to unity and (possibly) subject to a short-sales constraint. The test consisted of comparing the optimal portfolio of an investor who ignores the relation between market shocks and the correlations between the returns on the risky securities (Investor I), to a portfolio of an investor who accounts for this relation (Investor A). When choosing the optimal portfolio, Investor A is assumed to know that there exists a relation between the size of market shocks and the correlations of asset returns; thus, in choosing the portfolio the investor accounts for the current regime, which could either be a "high" shock or a "low" shock regime.

The only difference between the computations for the investors is that for Investor I, the mean, variance and correlations of the processes for the risky assets are calibrated using the entire time series of returns, while for Investor A, the data is first sorted by aggregate shock size, and then separate means, variances and correlations are computed for the data in the high-shock states and that for the low-shock states (as in Table 2, right).[6] The estimates from each subsample were then used to calibrate the return distribution for the high shock states and the low shock states, and the portfolios are computed for each regime. Given that the objective is to compare the portfolios of investors who account for the variation in the correlations and investors who ignore this, no attempt is made to impose any additional constraints in order to generate portfolio weights that are "reasonable" from a client's perspective.

The results from the above experiment are reported in two tables: Table 4 (page 10) where short sales are prohibited, and Table 5 (page 10) where short sales are allowed. In the high shock state (in Table 4) the investor tends to bias the portfolio towards the less risky asset, the U.S. equity index, while in the low state there is more investment in the Italian equity index. For example, for the case where relative risk aversion is equal to two, in the low shock state the portfolio weight on the U.S. index is zero and the entire portfolio is invested in the Italian index, but in the high shock state the investment in the Italian index drops and that in the U.S. market increases to 0.2901. The magnitude of the change in the portfolio increases with risk aversion. Comparing the portfolio weights of Investor I to that of the Investor A, it can be seen that when risk aversion is high the Investor A holds much more of the U.S. asset.

For the case where short sales are

Table 2

Correlations and system shocks

The correlation changes depend on the level of the shock. The first entry in the cell gives correlations in the low shock states, the second entry gives correlations in the high shock states and the third entry depicts the difference (high-low) between the first two correlations.

Country	Italy	Canada	Germany	Japan	Switzerland	UK	U.S.
IT: low	1.00						
IT: high	1.00						
IT: high-low	0.00						
CA	0.17	1.00					
CA	0.35	1.00					
CA	0.18	0.00					
GE	0.20	-0.10	1.00				
GE	0.39	0.46	1.00				
GE	0.19	0.56	0.00				
JA	0.12	0.11	-0.05	1.00			
JA	0.46	0.41	0.46	1.00			
JA	0.34	0.30	0.51	0.00			
SZ	0.15	0.10	0.30	0.09	1.00		
SZ	0.44	0.67	0.75	0.48	1.00		
SZ	0.30	0.57	0.44	0.39	0.00		
UK	-0.01	0.01	0.14	0.04	0.15	1.00	
UK	0.52	0.61	0.53	0.47	0.64	1.00	
UK	0.53	0.60	0.39	0.43	0.36	0.00	
U.S.	0.02	0.45	0.03	0.05	0.05	0.06	1.00
U.S.	0.30	0.78	0.47	0.42	0.65	0.61	1.00
U.S.	0.28	0.33	0.44	0.37	0.60	0.55	0.00

Data is from August 1976-July 1992.

Correlations between returns on a U.S. portfolio only are similiar.

	Decile-1	Decile-4	Decile-7	Decile-10
Decile-1: low	1.00			
Decile-1: high	1.00			
Decile-1: hi-lo	0.00			
Decile-4	0.67	1.00		
Decile-4	0.93	1.00		
Decile-4	0.26	0.00		
Decile-7	0.55	0.81	1.00	
Decile-7	0.85	0.97	1.00	
Decile-7	0.30	0.16	0.00	
Decile-10	0.22	0.48	0.71	1.00
Decile-10	0.65	0.83	0.90	1.00
Decile-10	0.43	0.34	0.19	0.00

Data is from January 1971 to December 1994.

Correlations between different U.S. asset classes show the same pattern.

	S & P 500	Small Stocks	Govt. Bonds
S&P 500: low	1.00		
S&P 500: high	1.00		
S&P 500: hi-lo	0.00		
Small Stocks Index	0.52	1.00	
Small Stocks Index	0.81	1.00	
Small Stocks Index	0.29	0.00	
Govt. Bonds Index	0.15	0.03	1.00
Govt. Bonds Index	0.40	0.24	1.00
Govt. Bonds Index	0.25	0.21	0.00

Data is from January 1971 to December 1994.

Table 4

Constructing a portfolio, with no shorting

In a high shock state the optimal portfolio is biased towards the less risky U.S. equity index, while in a low shock state the bias is towards the Italian equity index.

	Portfolio Weighting								
	Risk aversion = 2			Risk aversion = 4			Risk aversion = 6		
Asset	Inv. I	High	Low	Inv. I	High	Low	Inv. I	High	Low
Riskfree	0.00	0.00	0.00	0.41	0.00	0.00	0.60	0.00	0.00
IT	0.20	0.71	1.00	0.11	0.45	1.00	0.07	0.35	1.00
CA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JA	0.01	0.00	0.00	0.04	0.00	0.00	0.03	0.00	0.00
NE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SZ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UK	0.26	0.00	0.00	0.13	0.00	0.00	0.09	0.00	0.00
U.S.	0.53	0.29	0.00	0.31	0.55	0.00	0.21	0.65	0.00

permitted (Table 5) the investment in the U.S. asset is larger in the high shock state compared to the low shock state, and it increases with risk aversion. Compared to the portfolio of Investor I, the portfolio of Investor A in the high risk state has substantially more invested in U.S. equities.

Tables 4 and 5 indicate that the investor who accounts for the relation between market shocks and the correlation between asset returns, tends to bias the portfolio towards the less risky assets in the high shock state. Also note that the portfolio of Investor I is quite different from that of Investor A (in either state), and the naive investor's portfolio is not simply an average of the portfolio in the high and low state.

When It Is Needed The Most

The correlation across returns from international equity indices tends to increase with the size of the global shock. This variation in correlations points to reduced diversification benefits at times of high uncertainty, and is an important aspect to be considered by any individual, firm, or financial institution exposed to foreign assets or liabilities. This source of additional risk compounds the loss of diversification from increased correlations in the exchange rate markets over the last twenty years, as well as from increasing volatility of exchange rate returns. The analysis shows that, optimally, investors would adjust their portfolios invested in international assets to account for the increase in correlation across returns from international equities at times of high uncertainty in global markets. Following large shocks in the market, this adjustment leads to an increase in investment towards the less risky assets—the riskless asset and U.S. equities. We find that the correlation between returns on only U.S. assets also tends to increase with the size of the global shock.

From a practitioner's point of view, hedging is mandated for globally diversified portfolios: no longer can international asset managers exp-ect a large proportion of risk to be neutralized by pure diversification. Moreover, the analysis suggests an important role for active portfolio management. The results obtained in this study are relevant for short-horizon investors such as managers of international money market funds, international mutual fund managers who have longer investment horizons, central bankers who hold their reserves in a portfolio diversified across different currencies, corporate treasurers exposed to exchange rate risk, and writers of complex options whose exposure is a function of the covariation between different currencies.

ENDNOTES

1 *New York Times*, July 16, 1993.

2 Sorensen, E.H., J.J. Mezrich, and D.N. Thadani, "Currency Hedging Through Portfolio Optimization,'" *Journal of Portfolio Management*, 1993, v19(3), 78-85.

3 De Santis, G. and B. Gerard, "International Asset Pricing and Portfolio Diversification with Time-Varying Risk," Working Paper, 1995, UCLA; Longin Francois., and Bruno Solnik, "Is the Correlation in International Equity Returns Constant?" *Journal of*

Table 5

Constructing a portfolio, with shorting

When short sales are permitted, the investment in U.S. equities is larger in the high shock state, compared to the low shock state.

	Portfolio Weighting								
	Risk aversion = 2			Risk aversion = 4			Risk aversion = 6		
Asset	Inv. I	High	Low	Inv. I	High	Low	Inv. I	High	Low
Riskfree	-0.01	0.24	-13.74	0.47	0.17	-6.31	0.64	0.15	-3.85
IT	0.36	1.26	-1.39	0.16	0.74	-0.67	0.11	0.57	-0.44
CA	-0.40	-1.49	2.47	-0.20	-1.56	1.23	-0.13	-1.58	0.82
GE	0.04	-0.79	7.19	0.01	-0.75	3.32	0.01	-0.74	2.15
JA	0.05	0.00	2.28	0.09	0.00	1.18	0.06	0.00	0.80
NE	-0.29	-0.46	-1.74	-0.15	-0.35	-0.78	-0.10	-0.32	-0.50
SZ	-0.35	-1.30	4.03	-0.18	-1.15	1.93	-0.12	-1.10	1.30
UK	0.42	0.14	1.14	0.21	0.25	0.61	0.14	0.29	0.41
U.S.	1.19	3.40	0.75	0.57	3.65	0.45	0.38	3.73	0.31

This variation in correlations points to reduced diversification benefits at times of high uncertainty.

International Money and Finance, 1995, v14(1), 3-26; and, Karolyi, Andrew., and Rene Stulz, "Why Do Markets Move Together?" 1995, Working paper, Ohio State University.

4 See, Das, S. and R. Uppal "Optimal Portfolio Choice with Time and State Varying Correlations: A Theoretical and Empirical Analysis," UBC Working paper, 1996.

5 A similar analysis can be also be carried out in continuous time.

Consider the problem of an investor who wishes to maximize her expected utility of wealth next period by choosing the weights to allocate to the N risky assets and a riskless asset. The investor is assumed to have a disliking for risk and a preference for return, which can be represented by a standard utility function, $U(W)=W^{\eta}/\eta$, where W denotes wealth and $(1-\eta)$ is the coefficient of constant relative risk aversion. The portfolio weights for the N risky securities are denoted by w_i, i=1, N, while the weight on the riskless asset is given by

$$w_0 = 1 - \sum_{i=1}^{N} w_i$$

Assume that the set of possible return outcomes is discrete, and denote the return for the riskless asset as r, while that for the risky security i in state k is r_{ik}. Then, one can generate the processes for the risky assets so that they match the moments in the data.

We use the approach in He, Hua, "Convergence from Discrete- to Continuous-Time Contingent Claims Prices," *Review of Financial Studies,* 1990, v3(4), 523-546.

6 The results are similar when the portfolio computations are calibrated to the results in Tables 2 for U.S. assets.