Common Predictable Components in Regional Stock Markets

Yin-Wong Cheung
Economics Board, University of California, Santa Cruz, CA 95064

Jia He and Lilian K. Ng
Department of Economics and Finance, City University of Hong Kong, Hong Kong

This article employs recently developed multivariate methods to study the predictability of international stock-market returns. We find evidence of significant common predictable components within the Pacific, the European, and the North American stock markets using region-specific instrumental variables. The degree of predictability of these common movements, however, varies across regional markets and across subperiods. Results indicate that only North American instrumental variables have the ability to predict excess returns on the stock markets in the other two regions, but not vice versa.

KEY WORDS: Asset pricing; Linkages between national equity markets; Maximally predictable portfolio; Maximal R^2; Maximum latent root test.

The question of whether asset returns are predictable has been of longstanding interest to both academics and practitioners. Indeed, increasing empirical evidence (Fama and French 1988, 1989; Keim and Stambaugh 1986) has documented that U.S. stock and bond returns can be reliably predicted using variables such as dividend yields, short-term interest rates, and yield spreads. Bekaert and Hodrick (1992), Campbell and Hamao (1992), Ferson and Harvey (1993), and Harvey (1991) also presented similar evidence with other international stock-market data.

In this study we characterize the joint predictability of excess returns on international stock markets using a common set of ex ante observable economic variables. We examine evidence for the existence of common movement and interaction among national stock markets in the Pacific Rim, the European, and the North American regions. Motivated by the recent trend toward three trading blocs—Europe, North America, and Asia—the selection of these regions has significant implications for intraregional and interregional investments, especially for the operation of regional and international financial markets. Regional cooperation is mainly based on the premise that countries in a region linked by similar geographical, economic, financial, and political characteristics may be able to promote for mutually beneficial economic goals. These efforts are also directed toward the international level that is necessary for achieving a globally integrated economy.

To analyze these regional common movements, we investigate (a) whether a set of region-specific instrumental variables has forecasting power for excess returns on national stock markets of the same region and (b) whether similar instruments of one region can help predict equity returns of another. This approach contrasts with the existing studies (Bekaert and Hodrick 1992; Campbell and Hamao 1992) that examine either the effect of one country's variables on another country's stock returns or a sample of a few countries. It further provides a more comprehensive investigation of the regional markets' comovement. Any existence of such comovement indicates common linkages between national stock markets, and this finding will have an important implication for international asset-pricing theories.

In our analysis we employ three multivariate methodologies to test the significance of return predictability. In the spirit of Roll (1988), we use the maximal R^2 (the maximum coefficient of determination) procedure developed by Lo and MacKinlay (in press, hereafter LM) to determine the maximum predictability in stock returns. The attractiveness of this approach is that it allows us to gauge the statistical significance of the maximum predictability with respect to the selected instruments and hence to test for any spurious relationship between asset returns and the instruments employed.

Furthermore, we propose a maximum latent root test procedure that generalizes the LM maximal R^2 to test whether instruments of one region can predict equity returns of another. Conditional on a set of comparable domestic-region instruments, this approach evaluates the foreign instruments' maximum incremental predictive power for a domestic region's stock returns. Finally, the robustness of these results is investigated by using a Wald test.

Overall, we find evidence of comovement among regional stock markets. This result ties in with the growing economic and financial integration of the three regional countries. We also find that the North American region appears to be the most influential region in the world capital market; U.S. instruments have the ability to influence the European and Pacific Rim's stock-market movements, but this is not true in the other direction. This finding further strengthens previous evidence (Cheung and Ng 1996; Engle, Ito, and Lin 1990; Eun and Shim 1989; Hamao, Masulis, and Ng 1990) on the dominant role of the United States in the world economy.

Journal of Business & Economic Statistics
January 1997, Vol. 15, No. 1

The remainder of the article is organized as follows. Section 1 describes the data. Sections 2 and 3 present the empirical methodologies and results, and Section 4 contains a summary.

1. DATA DESCRIPTION

1.1 National Stock Returns

This study uses monthly data on 18 national stock indexes and two regional (European and Pacific) indexes from January 1970 to December 1991. These indexes, provided by Morgan Stanley Capital International (MSCI), are value-weighted, inclusive of dividends, and measured in U.S. dollars. Monthly excess returns are calculated as differences between returns on these national indexes and short-term U.S. treasury-bill rates, as provided by the Center for Research in Security Prices (CRSP).

The 18 national markets are grouped into (a) the Pacific Rim (PAC) region consisting of Australia, Hong Kong, Japan, and Singapore/Malaysia; (b) the North American (NA) region consisting of Canada and the United States, and (c) the European (EUR) region consisting of Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom. We define ZP_t, ZN_t, and ZE_t as vectors of excess returns on national equity markets from time $t-1$ to t in the PAC, NA, and EUR regions.

1.2 Instrumental Variables

Because it is not our intention to arbitrarily select the best combination of forecasting variables, our choice of instrumental variables is mainly drawn from existing theoretical and empirical studies (Bekaert and Hodrick 1992; Campbell and Hamao 1992; Ferson and Harvey 1993; Harvey 1991; LM; Solnik 1993). Our selection of regional instruments relates most closely to LM and to Ferson and Harvey (1993). Given the paucity and quality of the data on regional markets, however, we only manage to obtain five comparable regional instrumental variables. We therefore select (a) the German interest rates as proxies for EUR interest rates because the European Economic Community is tightly anchored with the German mark, (b) the Japanese interest rates as proxies for PAC rates because of the dominant Japanese role in the region and in the world economy, and (c) the U.S. interest rates for the NA region.

The PAC instruments are the lagged excess return on the MSCI Pacific stock index (PRET_t), the dividend yield on PRET_t (PDY_t), the interest rate spread (JTERM_t) defined as the difference between the yield on the Japanese Central long-term government bonds with maturity of five years or more and short-term interest rate, the interest rate trend (JIRT_t) defined as the change of the yield on Japanese long-term government bonds, and the interaction variable ($\mathrm{PRET}_t^*\mathrm{PDY}_t$). The short-term interest rate is constructed from the call-money rate (71:1–76:12) and the three-month Gensaki rate (77:1–91:12). XP_t represents the vector that contains these five variables.

Here we briefly discuss the rationale behind the preceding choices. Ferson and Harvey (1993) showed that the lagged world index return has forecast power for national stock returns, and Cheung, He, and Ng (1994) found that PRET_t has similar predictive ability for stock-index returns in the Pacific Rim markets. Campbell and Shiller (1988) and Fama and French (1988) provided evidence that dividend yield has predictive power for U.S. stock returns. Dividend yields vary with expected returns—when required rates of return are high, stock prices are low relative to dividends and hence dividend yields are high. Fama (1984) and Keim and Stambaugh (1986) showed that term spreads forecast the time-varying term premium in stock returns. In essence, the JTERM variable captures the variation in stock returns in response to variation in business conditions. Consistent with LM, our study also includes the interest rate trend and the interaction variable. They found that the former predicts stock returns, whereas the latter captures time-varying stock-market betas.

The five EUR counterparts are the lagged excess return on the MSCI European stock index (ERET_t), the dividend yield on ERET_t (EDY_t), the interest rate spread (GTERM_t) defined as the difference between German long-term public-sector bond yields with 7–15 years of maturity and three-month interbank loan rates, the interest rate trend (GIRT_t) defined as the change in German long-term government bond yields, and the interaction variable ($\mathrm{ERET}_t^*\mathrm{EDY}_t$). XE_t represents these five variables.

The comparable NA instruments are the lagged excess return on the MSCI U.S. stock index (URET_t), the dividend yield on URET_t (UDY_t), the yield spread (TERM_t) defined as the difference between the CRSP long-term government bond return and the short-term U.S. treasury-bill rate, the interest-rate trend (IRT_t) defined as the monthly change of the yield on long-term government bonds, and the interaction variable ($\mathrm{URET}_t^*\mathrm{UDY}_t$). These five variables are collectively denoted by XN_t.

2. METHODOLOGY

Let $Z_t = (Z_{1,t}, \ldots, Z_{N,t})'$ be the generic notation for a vector of excess returns on N national stock markets. Z_t is assumed to be stationary and ergodic. $X_{t-1} = (X_{1,t-1}, \ldots, X_{K,t-1}, 1)'$ is a $(K+1)$ vector containing K regional instruments and a constant. We express Z_t as

$$Z_t = B'X_{t-1} + \varepsilon_t, \tag{1}$$

where B is a $(K+1) \times N$ matrix of constant parameters, $E[\varepsilon_t|\Omega_{t-1}] = 0$, and $\mathrm{var}[\varepsilon_t|\Omega_{t-1}] = \Sigma$. Consistent with the existing literature, the information set Ω_{t-1} includes ex ante observable economic variables, such as lagged yield spreads, dividend yields, and aggregate market returns, that can be interpreted as proxies for expected risk premiums associated with macroeconomic risks. We also assume that the information structure $\{\Omega_t\}$ is well behaved such that the conditional expected return, $E[Z_t|\Omega_{t-1}]$, is stationary and ergodic. The conditional heteroscedasticity in Z_t is captured by that in $E[Z_t|\Omega_{t-1}]$. See LM for a more detailed discussion on model specification.

With a properly defined intercept term, (1) encompasses the intertemporal capital asset-pricing models (Merton 1973), the multifactor models (Ferson and Harvey 1993; He, Kan, Ng, and Zhang 1995), and many other linear asset-pricing models. Thus, (1) provides a natural framework to study common movements in national equity markets driven by the selected regional instruments.

Suppose that $\gamma = (\gamma_1, \ldots, \gamma_N)'$ is a vector of portfolio weights that sum to 1. Then $\gamma' Z_t$ is the return on a portfolio, which is a linear combination of excess returns Z_t. The relation of $\gamma' Z_t$ and X_{t-1} can be described as follows:

$$\gamma' Z_t = \gamma' B' X_{t-1} + \gamma' \varepsilon_t. \tag{2}$$

The best linear relation between $\gamma' Z_t$ and X_{t-1} can be obtained by varying γ such that the explained fraction of the variability in $\gamma' Z_t$ due to the conditional expectation of $\gamma' Z_t$ is maximized. Constructing this portfolio maximizes the predictability of the instruments and hence yields the highest R^2. This procedure is discussed in Subsection 2.1.

2.1 The Maximal R^2

When regressing γZ_t on X_{t-1}, the R^2 is given by

$$R^2(\gamma) \equiv 1 - \frac{\mathrm{var}[\gamma' \varepsilon_t]}{\mathrm{var}[\gamma' Z_t]} = 1 - \frac{\gamma' \Sigma \gamma}{\gamma' \Gamma_z \gamma} = \frac{\gamma' \Gamma_x \gamma}{\gamma' \Gamma_z \gamma}, \tag{3}$$

where $\Gamma_x \equiv \mathrm{var}[B' X_{t-1}]$ and $\Gamma_z \equiv \mathrm{var}[Z_t]$. LM's proposition 1 shows that the maximum $R^2(\gamma)$ and the corresponding portfolio γ are given, respectively, by the largest latent root of the matrix $L = \Gamma_z^{-1} \Gamma_x$ and the associated latent vector. The portfolio with the maximal $R^2(\gamma)$ shall be referred to as the maximally predictable portfolio (MPP). The MPP allows us to infer the maximum predictive power of the selected instruments for a set of national stock indexes. Throughout our analysis, the maximal $\bar{R}^2(\gamma)$ [the maximal $R^2(\gamma)$ adjusted for the number of regressors in the model] is used. Because $\bar{R}^2(\gamma)$ is proportional to $R^2(\gamma)$, maximizing $\bar{R}^2(\gamma)$ is equivalent to maximizing $R^2(\gamma)$.

The MPP method is also in the spirit of risk reduction. Forming stock portfolios helps reduce return variability by eliminating unsystematic risk in individual stocks. In constructing the MPP, we maximize the explanatory power by explicitly adjusting the portfolio weights such that the unexplained excess stock-return variability is minimized. To account for the possible bias imparted by the in-sample γ-searching process, LM derived the distribution of the maximal $\bar{R}^2(\gamma)$ under the normality assumption and under the null hypothesis that X_t has no effect on γZ_t. The conditional homoscedasticity and normality assumptions of ε_t's do not imply that Z_t's are unconditionally homoscedastic and normal. When ε_t's are conditionally heteroscedastic, a general central limit theorem can be used to derive the asymptotic distribution. See the related discussion by LM. It is, however, computationally intractable to tabulate the critical values of the maximal $\bar{R}^2(\gamma)$ for all the relevant N, K, and sample sizes. Thus the Monte Carlo method is used to generate the required critical values; the method and the simulated critical values are reported in the Appendix.

2.2 The Maximum Latent Root Test

The regression model

$$\begin{aligned} Z_t &= B_F' X_{F,t-1} + B_D' X_{D,t-1} + b + \varepsilon_t \\ &\equiv B' X_{t-1} + \varepsilon_t \end{aligned} \tag{4}$$

is used to investigate foreign instruments' effects on a domestic region's stock returns. Z_t and $X_{D,t-1}$ are the excess equity returns and instruments from the same region, whereas the $X_{F,t-1}$ vector denotes P instruments from a foreign region. B_F and B_D are the $P \times N$ and $(K-P) \times N$ coefficient matrices, and b is a constant vector. The incremental predictability of $X_{F,t-1}$ in the domestic markets can be tested via a linear restriction hypothesis in the multivariate linear model. Specifically, the null hypothesis $RB = 0$, where $R = [I_p 0]$, tests the foreign instruments' incremental predictability. For notational convenience, we stack the observations and get $Z = XB + \varepsilon$.

Let $\bar{\Sigma}$ and $\hat{B}$ be the maximum likelihood estimates of Σ and B and the matrices S and Q be defined as follows:

$$S \equiv \hat{B}' R' [R(X'X)^{-1} R']^{-1} R \hat{B} = Z_1^{*\prime} Z_1^* \tag{5}$$

and

$$Q \equiv T \hat{\Sigma} = Z'Z - \hat{B}' X' Z = Z_3^{*\prime} Z_3^*. \tag{6}$$

Under the normality assumption, the distributions of Z_1^* and Z_3^* (Muirhead 1982, p. 436) are given by $Z_1^* \sim N(M_1, I_p \otimes \Sigma)$ and $Z_3^* \sim N(0, I_{(T-K-1)} \otimes \Sigma)$, where M_1 is the expected value of Z_1^* and T is the sample size.

Given $X_{D,t-1}$, the incremental proportion of variation in the linear combination of Z_t attributable to $X_{F,t}$ takes the form of

$$R^2(\gamma) = \frac{\gamma' \Gamma_{XD} \gamma}{\gamma' \Gamma_{ZD} \gamma}, \tag{7}$$

where γ is the vector of portfolio weights, $\Gamma_{XD} \equiv \mathrm{var}[B' X_{t-1} | X_{D,t-1}]$, and $\Gamma_{ZD} \equiv \mathrm{var}[Z_t | X_{D,t-1}]$. It can be shown that

$$\Gamma_{XD} = B_F' [\Sigma_{FF} - \Sigma_{FD} \Sigma_{DD}^{-1} \Sigma_{DF}] B_F \tag{8}$$

and

$$\Gamma_{ZD} = \Gamma_{XD} + \Sigma, \tag{9}$$

where $\Sigma_{FF} \equiv \mathrm{var}[X_{F,t-1}]$, $\Sigma_{DD} \equiv \mathrm{var}[X_{D,t-1}]$, and $\Sigma_{FD} \equiv \mathrm{cov}[X_{F,t-1}, X_{D,t-1}]$. The estimators of Γ_{ZD} and Γ_{XD} can be written (Muirhead 1982, p. 580) as

$$\hat{\Gamma}_{ZD} = \hat{\Gamma}_{XD} + T^{-1} Q \tag{10}$$

and

$$\hat{\Gamma}_{XD} = T^{-1} S, \tag{11}$$

where the matrices Q and S are given by (5) and (6). It can be shown that the maximum value of $R^2(\gamma)$ and the corresponding portfolio γ^* are given by l, the largest latent root of the matrix $(Q+S)^{-1} S$, and the latent vector associated with this latent root. When $P = K$ (i.e., there is no $X_{D,t-1}$

Table 1. Adjusted R^2's Obtained From Regressing Monthly Excess Returns on Regional Stock Market Indexes Against Region-Specific Instruments

Country	1970:1–1991:12	1970:1–1980:12	1981:1–1991:12
Panel A: The North American stock markets			
Canada	.08	.04	.20
U.S.	.08	.07	.21
Panel B: The Pacific Rim stock markets			
Australia	.03	−.02	.14
Hong Kong	.02	−.01	.08
Japan	.02	.06	.03
Singapore/Malaysia	.02	.02	.02
Panel C: The European stock markets			
Austria	.04	.01	.04
Belgium	.02	−.02	.03
Denmark	.02	.02	.01
France	.01	.03	.00
Germany	−.01	.00	−.03
Italy	−.01	−.01	−.01
Netherlands	.02	.01	.01
Norway	−.01	−.02	.01
Spain	.03	.01	.01
Sweden	.01	−.04	.04
Switzerland	.01	.01	−.03
U.K.	.04	.06	.02

NOTE: See Section 1 for definitions of the instruments used.

in the regression), (7) is reduced to (3). The resulting l statistic collapses to the LM maximal R^2. Thus, the latter is a special case of the maximum latent root method, which admits a more general conditional information set when calculating the maximum incremental explanatory power of the instruments.

The distribution of l under the null hypothesis $RB = 0$ can be derived using results in multivariate analysis and LM (Cheung, He, and Ng 1995). Similar to the case of maximal $\bar{R}^2(\gamma)$, simulated critical values of the l statistic are used. Both the simulation method and the critical values are given in the Appendix.

2.3 The Wald Test

Gourieroux, Monfort, and Renault (1991) applied the canonical analysis to examine the null hypothesis $RB = 0$. They showed that the Wald statistic for testing $RB = 0$ is given by

$$W = T \sum_{i=1}^{N} \omega_i/(1 - \omega_i),$$

where ω_i's are the latent roots of the matrix $(Q + S)^{-1}S$. Note that the W and l statistics are constructed differently. Under the null hypothesis, W has an asymptotic chi-square distribution with $P \times N$ df, and its asymptotic result does not depend on the normality assumption. This Wald test offers a means to assess the robustness of the results derived from the maximal $\bar{R}^2$ and l test statistics. In contrast, the MPP and l statistics provide a measure for the maximum explained variation in equity returns.

3. EMPIRICAL RESULTS

We report results based on the entire sample (1970:1–1991:12) and two subsamples (1970:1–1980:12 and 1981:1–1991:12). Including two nonoverlapping subsamples allows us to study the stability of the regression relationship across time. Because the 1980s represent a much more deregulated financial environment, it offers a contrast to the first subperiod.

3.1 Regional Stock Markets

The predictive power of local regional instruments is examined by using the following regressions:

$$ZP_t = B'XP_{t-1} + b + \varepsilon_t, \tag{12}$$

$$ZN_t = B'XN_{t-1} + b + \varepsilon_t, \tag{13}$$

and

$$ZE_t = B'XE_{t-1} + b + \varepsilon_t. \tag{14}$$

Variables in (12)–(14) are defined in Section 1. The pattern of the coefficient estimates is consistent with those reported in the literature. In the interest of brevity, we only report the $\bar{R}^2$'s in Table 1. Results on individual country regressions and diagnostic tests are available from us. The table shows that for some countries there is evidence of parameter instability across subsamples. For instance, the $\bar{R}^2$ for Australia increases from -2% in the first subsample to 14% in the second. This observation is probably attributed to changing effects of instrumental variables on excess returns across subsamples, reflecting a shift in the nature of the economic forces behind the common regional movement.

Comovement among stock-market excess returns is observed to vary across regions and across subperiods. The $\bar{R}^2$'s range from -1% to 8% for the full sample and from -4% to 21% for the subsamples. These values are similar to those obtained by Campbell and Hamao (1992) and Fer-

Table 2. Regression Results of Regional Maximally Predictable Portfolios Derived From Monthly Excess Returns on Regional Stock Indexes Against Region-Specific Instruments: NA MPP

Subsamples	CONS	URET	UDY	TERM	IRT	URET * UDY	$\bar{R}^2(\gamma)$	Wald stat.
1970:1–1991:12	−1.50	.45	23.49	7.94	−9.82	−1.25	.09*	41.04*
1970:1–1980:12	−4.45	.47	17.13	10.47	−3.39	−1.42	.07+	20.98*
1981:1–1991:12	1.31	.39	68.57	3.68	−30.13	−1.68	.24*	53.58*

NOTE: The NA MPP is constructed from the stock indexes in the NA region, which includes Canada and the United States. The instrumental variables are defined in Section 1. The full sample is 1970:1–1991:12, the first subsample is 1970:1–1980:12, and the second subsample is 1981:1–1991:12. $\bar{R}^2$'s are adjusted for degrees of freedom. The Wald statistics are distributed χ^2 with (N*5) df. "+" denotes significance at the 10% level. "*" denotes significance at the 5% level.

Table 3. Regression Results of Regional Maximally Predictable Portfolios Derived From Monthly Excess Returns on Regional Stock Indexes Against Region-Specific Instruments: PAC MPP

Subsample	*CONS*	*PRET*	*PDY*	*JTERM*	*JIRT*	*PRET *PDY*	$\bar{R}^2(\gamma)$	*Wald stat.*
1970:1–1991:12	.61	.07	.57	.92	−38.51	.43	.05	30.09
1970:1–1980:12	−3.49	.13	18.16	7.49	−3.89	.22	.06	17.50
1981:1–1991:12	2.05	−.02	−3.82	−29.98	−74.02	.07	.17*	43.66*

NOTE: The PAC MPP is constructed from the stock indexes in the PAC region, which includes Australia, Hong Kong, Japan, and Singapore/Malaysia. The instrumental variables are defined in Section 1. The full sample is 1970:1–1991:12, the first subsample is 1970:1–1980:12, and the second subsample is 1981:1–1991:12. $\bar{R}^2$'s are adjusted for degrees of freedom. The Wald statistics are distributed χ^2 with (N^*5) df. "*" denotes significance at the 5% level.

son and Harvey (1993), who performed country regressions against country-specific instruments.

Several diagnostic statistics were performed to check the adequacy of this conditional homoscedastic assumption. Throughout this study, we examined the first 12 lags of the resulting residuals. We could not reject the hypothesis that there exists no serial correlation or autoregressive conditional heteroscedasticity. Both tests were evaluated at the 5% significance level. Most regressions, however, fail the Jarque–Bera normality test. This makes the robust Wald test a valuable complement to the MPP approach for evaluating the explanatory power of the instruments.

The preceding parameter estimates are then used to construct the MPP. The estimated relations between the excess returns on each region MPP and its corresponding instruments are summarized in Tables 2–4. The $\bar{R}^2(\gamma)$'s in these tables are as large as, or larger than, those reported in Table 1. The EUR MPP's exhibit the most pronounced increase in the $\bar{R}^2(\gamma)$, whereas the NA MPP's have $\bar{R}^2(\gamma)$'s similar to the largest individual $\bar{R}^2$ attained in the NA region.

The significance of the MPP $\bar{R}^2(\gamma)$'s is evaluated based on the simulated critical values given in Table A.1 in the Appendix. The NA MPP $\bar{R}^2(\gamma)$'s are found to be significant at the 5% level for both the entire period and the second subsample and only at the 10% level for the first subsample. The observed comovement of the U.S. and Canadian stock markets seems stronger over time. This predictable movement perhaps manifests the two countries' growing economic and financial integrations.

The PAC MPP $\bar{R}^2(\gamma)$'s improve by at least twofold across the two subsamples. Only the $\bar{R}^2(\gamma)$ for the second subsample is reliably significant. This evidence is consistent with capital-market developments of the PAC region in the 1980s. Although barriers to capital movements were commonly implemented in the 1970s, the gradual removal of capital controls in Japan and the other PAC countries after 1980 has promoted and enhanced their capital market integration.

The EUR MPP's, however, yield different results. Although all the $\bar{R}^2(\gamma)$'s are larger than those based on individual country regressions, their level of statistical significance differs across sample periods. The $\bar{R}^2(\gamma)$'s are significant at the 5% level for both the entire sample and the first subsample and at the 10% level for the second. The results indicate that the effect of the instruments on the portfolio return has changed over time. The weak comovement in the second subperiod may be attributable to different economic developments and growths in the 1980s. For instance, the exchange-rate mechanism of the European Monetary System, which was designed to promote economic cooperation among member countries, has undergone several crises over the past decade. As a result, these exchange rates have been realigned more than 10 times between 1981 and 1991. Given the diverse economic conditions, the underlying forces driving the common predictable component of this region are more likely to change during the 1980s.

Compared with the $\bar{R}^2(\gamma)$'s, the sample W statistics usually have a smaller marginal significance level (not reported), thereby providing stronger evidence for predictability in regional markets. Moreover, in contrast to maximal $\bar{R}^2(\gamma)$'s, the Wald test finds a more significant common component in the EUR region for the second subperiod. Because the W statistic is (asymptotically) robust to distributional assumptions, the less significant $\bar{R}^2(\gamma)$ may be induced by nonnormal errors.

Panels A, B, and C of Table 5 show portfolio weights of the three regional MPP's. No discernible pattern in the portfolio weights prevails across the sample period. These weights provide some insights concerning the sources of predictability, however. For example, the Australian stock index is important for maximizing predictability of returns over the full period (42%) and the second subperiod (63%), whereas the Japanese stock index plays a

Table 4. Regression Results of Regional Maximally Predictable Portfolios Derived From Monthly Excess Returns on Regional Stock Indexes Against Region-Specific Instruments: EUR MPP

Subsample	*CONS*	*ERET*	*EDY*	*GTERM*	*GIRT*	*ERET *EDY*	$\bar{R}^2(\gamma)$	*Wald stat.*
1970:1–1991:12	20.50	2.70	−55.73	−16.29	27.79	−4.23	.15*	118.62*
1970:1–1980:12	30.97	−1.48	−77.58	0.98	17.83	3.29	.28*	107.24*
1981:1–1991:12	−33.45	7.89	13.00	−11.25	−40.82	−3.62	.20+	106.76*

NOTE: The EUR MPP is constructed from the stock indexes in the EUR region, which includes Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom. The instrumental variables are defined in Section 1. The full sample is 1970:1–1991:12, the first subsample is 1970:1–1980:12, and the second subsample is 1981:1–1991:12. $\bar{R}^2$'s are adjusted for degrees of freedom. The Wald statistics are distributed χ^2 with (N^*5) df. "+" denotes significance at the 10% level. "*" denotes significance at the 5% level.

Table 5. Portfolio Weights of Maximally Predictable Portfolios for Monthly Excess Returns on the Regional Stock-Market Indexes

Stock indexes	*1970:1–1990:12*	*1970:1–1980:12*	*1981:1–1990:12*
Panel A: The North American stock markets			
Canada	.50	.08	.38
U.S.	.50	.92	.62
Panel B: The Pacific Rim stock markets			
Australia	.42	−.04	.63
Hong Kong	.17	−.01	.22
Japan	.26	.86	.20
Singapore/Malaysia	.15	.19	−.04
Panel C: The European stock markets			
Austria	2.70	2.05	.43
Belgium	−.09	.79	.43
Denmark	−.31	.34	−.20
France	−.34	−.86	.09
Germany	−1.09	−1.59	−.40
Italy	.26	−.19	.15
Netherlands	−.91	−1.04	−.41
Norway	1.39	.43	.16
Spain	1.81	.96	.08
Sweden	.35	−.14	−.38
Switzerland	−1.04	.95	.19
U.K.	−1.72	−.70	−.12

more significant role in the first subperiod (86%).

For practical purposes, one may want to construct the constrained MPP with nonnegative portfolio weights, which can be obtained numerically by incorporating the restriction $\gamma \geq 0$ in the algorithm used to maximize $R^2(\gamma)$. We estimated both the unconstrained and constrained MPP's. Because the two results are qualitatively similar and our focus is on predictability, we only report results based on the unconstrained specification.

3.2 Interactions Between Regional Stock Markets

The regression results using Equation (4) are summarized in Tables 6, 7, and 8. The first column of the tables labels the local markets; the region codes (NA, PAC, and EUR) under the sample periods indicate the type of foreign instruments added to the local instruments in the estimation. Including European and Pacific Rim instruments does not help to improve the NA $\bar{R}^2$'s, but adding NA instruments tends to increase, on average, the PAC $\bar{R}^2$'s by 2% and the EUR $\bar{R}^2$'s by 4%. Formal tests of this incremental predictability, as dictated by the l and W statistics, are given in Table 9. The first column labels the foreign instruments and test statistics, whereas the first row labels the domestic region of interest. The subscripts F, 1, and 2 indicate the statistics computed for the full sample and the first and second subsamples.

Table 6. Adjusted R^2's Obtained From Regressing Monthly Excess Returns on Regional Stock-Market Indexes Against Domestic and Foreign Instrumental Variables: The North American Stock Markets

Local markets	*1970:1–1991:12*		*1970:1–1980:12*		*1981:1–1991:12*	
	PAC	*EUR*	*PAC*	*EUR*	*PAC*	*EUR*
Canada	.09	.09	.03	.05	.17	.19
U.S.	.08	.09	.06	.07	.23	.20

NOTE: The first column labels the local markets, and the region codes (NA, PAC, and EUR) that appear under each sample period heading indicate the foreign instruments that are added to the local instruments in the estimation. See Section 1 for definitions of the instruments used.

Table 7. Adjusted R^2's Obtained From Regressing Monthly Excess Returns on Regional Stock-Market Indexes Against Domestic and Foreign Instrumental Variables: The Pacific Rim Stock Markets

Local markets	*1970:1–1991:12*		*1970:1–1980:12*		*1981:1–1991:12*	
	NA	*EUR*	*NA*	*EUR*	*NA*	*EUR*
Australia	.08	.02	.03	.02	.14	.13
Hong Kong	.01	.01	−.02	−.04	.06	.10
Japan	.06	.03	.11	.04	.08	.06
Singapore /Malaysia	.04	.03	.01	.01	.09	.04

NOTE: See note to Table 6.

Based on the computed l statistics in Table 9, the NA instruments display the largest incremental predictability by capturing 37% of the return variability of the EUR portfolio in the second subperiod, but the PAC instruments have the smallest because they explain only about 3% of the NA portfolio's full-period return variability. The simulated critical values from Table A.2 in the Appendix reveal that the l statistics are significant only when the NA instruments are employed as foreign variables; that is, only the NA instruments have incremental predictive power for the other regions' stock movements. These findings are further reinforced by the robust Wald test, which also indicates that the EUR instruments have a significant effect on the PAC stock-market movements in the 1980s. The finding is in line with Europe's increasing trading activities with the Pacific Rim countries in that period.

Overall, both of the multivariate tests indicate significant linkage between these three regional stock markets. The interaction is mainly dominated by influences of the NA instruments on the other regional stock markets. This finding further corroborates the previous literature on the leading role of the U.S. financial market in the world economy.

4. SUMMARY

Multivariate methods are employed to study common

Table 8. Adjusted R^2's Obtained From Regressing Monthly Excess Returns on Regional Stock-Market Indexes Against Domestic and Foreign Instrumental Variables: The European Stock Markets

Local markets	*1970:1–1991:12*		*1970:1–1980:12*		*1981:1–1991:12*	
	NA	*PAC*	*NA*	*PAC*	*NA*	*PAC*
Austria	.04	.02	.02	−.01	.03	.03
Belgium	.08	.01	.07	−.01	.15	.05
Denmark	.02	.03	.07	.03	.06	−.02
France	.06	.00	.06	.03	.08	.02
Germany	.03	−.01	.08	.00	.04	−.03
Italy	.01	.00	.02	−.02	.01	.06
Netherlands	.06	.01	.05	.03	.15	.01
Norway	.01	.00	−.02	.02	.01	−.02
Spain	.03	.02	.06	−.02	−.01	.04
Sweden	.03	.00	−.05	−.04	.20	.01
Switzerland	.08	.00	.11	.01	.07	−.04
U.K.	.06	.02	.08	.05	.06	.03

NOTE: See note to Table 6.

Table 9. Results of the Maximum Latent Root and the Wald Tests on the Incremental Predictability of Foreign-Region Instruments in the Presence of Local Regional Variables

Region	NA region	PAC region	EUR region
NA			
l_F		.090*	.134*
l_1		.121	.257*
l_2		.155*	.367*
W_F		38.853*	86.284*
W_1		28.293	103.43*
W_2		36.921*	117.22*
PAC			
l_F	.029		.105
l_1	.050		.154
l_2	.058		.205
W_F	14.358		54.782
W_1	10.767		68.147
W_2	9.317		59.221
EUR			
l_F	.042	.036	
l_1	.054	.088	
l_2	.058	.122	
W_F	12.289	19.505	
W_1	10.709	17.698	
W_2	10.382	34.333*	

NOTE: The first column indicates the foreign region and the first row indicates the local region. l and W are the maximum latent root and Wald statistics, with subscripts F, 1, and 2 denoting the sample period (F = full sample, 1970:1–1991:12; 1 = first subsample, 1970:1–1980:12; and 2 = second subsample, 1981:1–1991:12) from which the statistic is calculated. For example, .090 is the maximum latent root statistic computed from the full sample for testing the incremental predictability of the NA instruments in the PAC region stock movements in the presence of PAC instruments. See Section 1 for the description of the regional stock indexes and the instruments. "*" denotes significance at the 5% level.

predictable components in the North American, the Pacific Rim, and the European stock markets by using similar region-specific instruments. The maximal $\bar{R}^2$ method determines the largest portion of return variability that can be captured by the selected instruments, and the maximal latent root test gives the maximum predictive power of one set of instruments conditional on another. Additionally, a Wald statistic is performed to examine the robustness of these results.

These approaches provide strong evidence of common predictable components in the three regional stock markets. The degree of predictability, however, varies over time and across regions. The common movements in the Pacific Rim and North American regions are stronger in the 1980s than in the 1970s, but those in the European tend to be stronger in the 1970s than in the 1980s.

The results show that North American instruments have the ability to influence stock markets in both the European and Pacific Rim regions. The European and Pacific Rim instruments, however, exhibit weak predictive power for the other regional stock-market movements. Although evidence for common movement between the European and Pacific Rim markets seems weak, their interactions with the North American markets are statistically significant.

ACKNOWLEDGMENTS

We thank Jan Annaert, K. C. Chan, Nai-Fu Chen, Ravi Jagannathan, George Tauchen (the editor), Raman Uppal, an anonymous associate editor, two anonymous referees, and workshop participants at the 1993 European Finance Association Meetings in Copenhagen, University of Houston, the University of Texas at Austin, and the Hong Kong University of Science and Technology for helpful comments and suggestions.

APPENDIX: MONTE CARLO SIMULATIONS

In this appendix we present Monte Carlo results for the finite-sample distributions of the maximal $\bar{R}^2(\gamma)$ and the maximum latent root statistic l for a given portfolio under the null hypothesis of no predictability.

For a portfolio consisting of N assets and a sample size T, we generate T $N \times 1$ standard multivariate Gaussian vectors. Note that, under the null hypothesis, the distributions of both the maximal $\bar{R}^2(\gamma)$ and the l statistics do not depend on the variance–covariance structure of the data. There are 273 observations in the full sample, 131 in the first subsample, and 132 in the second subsample. N is set equal to 4 for the PAC case, 2 for the NA case, and 12 for the EUR case.

For the maximal $\bar{R}^2(\gamma)$ statistic, the LM procedure is used to compute the $\bar{R}^2(\gamma)$ of the MPP constructed from simulated random vectors and the corresponding instrumental

Table A.1. Simulated Finite-Sample Distributions of the $\bar{R}^2$ for the Maximally Predictable Portfolios of Different Assets Under the Null Hypothesis of No Predictability

Region	Mean	S.D.	Min	Max	1%	5%	10%	50%	90%	95%	99%
					T = 263						
NA	.014	.014	−.013	.092	−.008	−.004	−.002	.012	.033	.039	.057
PAC	.030	.016	−.008	.132	.002	.008	.012	.028	.051	.059	.075
EUR	.079	.021	.023	.195	.040	.049	.054	.077	.107	.116	.134
					T = 131						
NA	.029	.028	−.026	.242	−.017	−.008	−.003	.025	.066	.080	.111
PAC	.061	.031	−.010	.214	.005	.017	.025	.057	.103	.117	.149
EUR	.159	.039	.042	.331	.083	.101	.112	.156	.212	.228	.263
					T = 132						
NA	.029	.027	−.026	.206	−.017	−.008	−.003	.025	.066	.079	.113
PAC	.061	.031	−.013	.249	.006	.017	.024	.057	.102	.117	.147
EUR	.157	.038	.043	.337	.081	.099	.111	.155	.198	.227	.257

NOTE: NA = the North American portfolio; PAC = the Pacific Rim portfolio; EUR = the European portfolio; T = the sample size. The regional instruments are used to generate the preceding critical values for regional portfolios. For brevity, see Section 1 of the text for definitions of the instruments.

Table A.2. Simulated Finite-Sample Distributions for the Maximum Latent Root Statistic l Under the Null Hypothesis That the Additional Foreign-Region Factors Have No Predictability

	Mean	*S.D.*	*Min*	*Max*	*1%*	*5%*	*10%*	*50%*	*90%*	*95%*	*99%*
PEF	.095	.020	.040	.210	.057	.065	.070	.093	.122	.131	.150
PE1	.192	.039	.079	.382	.115	.133	.144	.189	.245	.261	.295
PE2	.191	.039	.080	.362	.115	.132	.143	.188	.242	.259	.292
NEF	.095	.021	.036	.187	.055	.065	.070	.093	.123	.132	.151
NE1	.192	.039	.073	.380	.114	.134	.144	.188	.243	.261	.296
NE2	.192	.039	.075	.382	.115	.134	.144	.189	.243	.261	.294
EPF	.045	.016	.008	.129	.018	.023	.027	.043	.066	.074	.090
EP1	.093	.032	.020	.297	.036	.048	.055	.089	.136	.151	.185
EP2	.092	.031	.019	.238	.036	.048	.056	.088	.134	.149	.178
NPF	.045	.016	.007	.149	.018	.023	.027	.043	.066	.074	.090
NP1	.092	.031	.018	.247	.036	.048	.056	.088	.134	.149	.182
NP2	.092	.031	.018	.247	.036	.048	.056	.088	.134	.149	.182
PNF	.030	.014	.004	.108	.007	.011	.014	.027	.048	.056	.072
PN1	.061	.028	.006	.224	.015	.023	.029	.057	.098	.113	.144
PN2	.061	.028	.006	.218	.015	.024	.029	.057	.099	.113	.144
ENF	.029	.014	.003	.112	.007	.011	.014	.027	.048	.054	.071
EN1	.061	.028	.005	.226	.016	.024	.029	.057	.098	.112	.145
EN2	.060	.028	.005	.224	.015	.023	.029	.056	.098	.112	.143

NOTE: The first column gives the case to which the finite-sample distribution is applied. The first letter indicates the foreign region, the second letter indicates the local region, and the third letter indicates the sample period. $N \equiv$ NA, $E \equiv$ EUR, $P \equiv$ PAC, $F \equiv$ the full sample, $1 \equiv$ the first subsample, and $2 \equiv$ the second subsample.

variables described in Section 1. For the maximum latent root test, the l statistic is calculated from generated random vectors and the corresponding regional and foreign instruments. The finite-sample distributions are given in Tables A.1 and A.2. Each empirical distribution is based on 10,000 replications.

[Received February 1994. Revised January 1996.]

REFERENCES

Bekaert, G., and Hodrick, R. (1992), "Characterizing Predictable Components in Excess Returns on Equity and Foreign Exchange Markets," *Journal of Finance*, 47, 467–509.

Campbell, J., and Hamao, Y. (1992), "Predictable Stock Returns in the United States and Japan: A Study of Long-Term Capital Market Integration," *Journal of Finance*, 47, 43–69.

Campbell, J., and Shiller, R. (1988), "The Dividend Price Ratio and Expectations of Future Dividends and Discount Factors," *Review of Financial Studies*, 1, 195–228.

Cheung, Y.-W., He, J., and Ng, L. (1994), "Pacific-Basin Stock Markets and Real Activity," *Pacific-Basin Finance Journal*, 2, 349–373.

——— (1995), "Common Predictable Components in Regional Stock Markets," working paper, University of California at Santa Cruz, Economics Dept.

Cheung, Y.-W., and Ng, L. (1996), "A Causality in Variance Test and Its Application to Financial Market Prices," *Journal of Econometrics*, 72, 33–48.

Engle, R. F., Ito, T., and Lin, W. L. (1990), "Meteor Showers or Heat Waves? Heteroskedastic Intra-Daily Volatility in the Foreign Exchange Market," *Econometrica*, 28, 525–542.

Eun, C., and Shim, S. (1989), "International Transmission of Stock Market Movements," *Journal of Financial and Qualitative Analysis*, 24, 241–256.

Fama, E. (1984), "The Information in Term Structure," *Journal of Financial Economics*, 13, 509–528.

Fama, E., and French, K. (1988), "Dividend Yields and Expected Stock Returns," *Journal of Financial Economics*, 22, 3–25.

——— (1989), "Business Conditions and Expected Stock Returns on Stocks and Bonds," *Journal of Financial Economics*, 25, 23–49.

Ferson, W., and Harvey, C. (1993), "The Risk and Predictability of International Equity Returns," *Review of Financial Studies*, 6, 527–566.

Gourieroux, C., Monfort, A., and Renault, E. (1991), "A Framework for Factor Models," Working Paper 9107, INSEE.

Hamao, Y., Masulis, R., and Ng, V. (1990), "Correlations in Price Changes and Volatility Across International Stock Markets," *Review of Financial Studies*, 3, 281–307.

Harvey, C. (1991), "The World Price of Covariance Risk," *Journal of Finance*, 46, 111–157.

He, J., Kan, R., Ng, L., and Zhang, C. (1995), "Tests of the Relations Among Marketwide Factors, Firm-Specific Variables, and Stock Returns Using a Conditional Asset Pricing Model," Working Paper Series 69, City University of Hong Kong, Dept. of Economics and Finance.

Keim, D., and Stambaugh, R. (1986), "Predicting Returns in the Stock and Bond Markets," *Journal of Financial Economics*, 17, 357–390.

Lo, A., and MacKinlay, C. (in press), "Maximizing Predictability in the Stock and Bond Markets," *Journal of Finance*, 51 or 52.

Merton, R. (1973), "An Intertemporal Capital Asset Pricing Model," *Econometrica*, 41, 867–887.

Muirhead, R. (1982), *Aspects of Multivariate Statistical Theory*, New York: John Wiley.

Roll, R. (1988), "R^2," *Journal of Finance*, 43, 541–566.

Solnik, B. (1993), "The Performance of International Asset Allocation Strategies Using Conditioning Information," *Journal of Empirical Finance*, 1, 33–55.