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STOCK MARKET INTEGRATION, RETURN FORECASTABILITY AND IMPLICATIONS FOR MARKET EFFICIENCY: A PANEL STUDY

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Abstract

Using a panel data set for 18 stock countries, this paper finds fairly strong integration among national equity markets. A country's stock index price can be decomposed into a common trend component and a stationary country-specific component. Results show that the 18 country indexes reverse to the world trend with a speed of 18% per year, and that the Hong Kong market converges to other markets with a speed of 22% per year or a half life of around three years. The two components can be separately estimated using maximum likelihood. The country-specific component displays substantial variability and is found to have both mean reversion over the long horizon and momentum over the short horizon. A simple parametric trading strategy exploiting simultaneously mean reversion and momentum effects produces an excess return of 16.7% per year, which exceeds those of strategies based on momentum or mean reversion separately. The excess return is statistically significant, and cannot be explained by systematic risk factors or by transaction costs. The results seem to support the behavioralist overreaction view vis-à-vis an efficient markets view.

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1. Introduction

Since the deregulation of financial markets started in the 1980s, the extent of international investments by investors worldwide has been steadily increasing. Investors (both institutional and individual) now allocate a substantially higher proportion of their financial wealth in international assets than two decades ago. As equity markets are becoming more open globally, understanding the extent of market integration and the implications for market efficiency is of great importance for policy makers and investors.

Whether stock markets are integrated is subject to much controversy. According to theoretical asset pricing models, such as Lucas (1978), if a group of economies show "convergence" in the sense of Barro and Sala-i-Martin (1995), then their stock prices should follow a common stochastic trend over the long-run and the values of representative firms in these countries should converge. Empirically, Kasa (1992) claims that stock indices between the U.S. and four other developed countries share one common stochastic trend. The implication of this result is that these equity markets are highly integrated, and that the value of a properly weighted portfolio of shares in these markets is stationary and thus will display mean reversion. On the other hand, Richards (1995) criticizes the results of Kasa (1992) on the grounds that the use of asymptotic critical values by Kasa in the cointegration tests is not appropriate. When finite-sample critical values are employed, however, Richards finds no significant evidence of market integration.

Using a panel approach, this paper finds strong evidence of integration among 18 national equity markets. Following Fama and French (1988), we decompose a country's stock index price into a common trend component and a stationary country-specific component. Our results show that the 18 country indexes reverse to the world trend with a speed of 18% per year, and that the Hong Kong market converges to other markets with a speed of 22% per year or a half life of around three years.

We then estimate separately the two components of stock price and study the implications of the model. We find that the country-specific component displays substantial variability and has both mean reversion over the long horizon and momentum over the short horizon. The variances of the mean reversion effect and the momentum effect are of comparable size, and both help explain the variations of returns. The temporary deviation from the common trend component is fairly strong which makes relative returns across countries predictable. A simple parametric trading strategy exploiting simultaneously mean reversion and momentum effects produces an excess return of 16.7% per year, which exceeds those of strategies based on momentum or mean reversion separately. The excess return is statistically significant and cannot be explained by systematic risk factors or transaction costs. The results seem to support the behavioralist overreaction view vis-à-vis an efficient markets view.

The remainder of the paper is organized as follows. Section 2 describes the model and a decomposition of expected returns into a common unconditional mean, the country-specific potential for mean reversion, and the country-specific potential for momentum. Section 3 presents the panel test for market integration. Section 4 studies the implications of the combination momentum and mean reversion strategies. Various robustness issues are covered in Section 5. Section 6 concludes the paper.

2. The Model and Return Decomposition

(a) An Integrated Mean Reversion-Momentum Model

We adapt the model of Fama and French (1988) and Summers (1986) to apply in a global context and to allow for momentum as well as mean reversion. First separate equity prices into permanent and temporary components; for country i, we have

$$p_t^i = y_t + x_t^i , \tag{1}$$

where p_t^i represents the log of the equity price index (with dividends reinvested) of country i. Superscripts everywhere indicate an individual country. The permanent price component is denoted by y_t and the temporary component by x_t^i .

Empirically, we consider portfolios for a homogeneous group of countries, which enables us to add some structure to the model. Specifically we assume that all permanent shocks are global, or, in other words, any country-specific shocks are transitory. The theoretical motivation is based on the idea of "convergence". Barro and Sala-i-Martin (1995) find that real per capita GDP across the 20 original OECD countries displays absolute convergence, implying that real per capita GDP in these countries converges to the same steady state. This would imply in models such as Lucas (1978) that values of representative firms in these countries should converge as well. As our sample consists of mainly OECD countries, we expect the non-global components in equity prices in these countries to be stationary.

The permanent component accordingly is fully global and is given as a random walk with drift as in Fama and French (1988):

$$y_t = y_{t-1} + \alpha_t . \tag{2}$$

The random term α_t is stationary with positive mean but otherwise unrestricted. The temporary component is a stationary process that allows for both mean reversion and momentum:

$$x_t^i = (1-\delta^i)\,\mu^i + \delta^i x_{t-1}^i + \sum_{j=1}^{k} \rho_j^i \,(x_{t-j}^i - x_{t-j-1}^i) + \eta_t^i . \tag{3a}$$

Equation (3a) thus generalizes the Fama and French (1988) and Summers (1986) model by allowing the ρ_j^i to be non-zero. The constant μ^i, the autoregressive coefficient δ^i, the momentum coefficients ρ_j^i , and the mean-zero normal random term η_t^i which is serially and cross-sectionally uncorrelated with variance $\sigma_{\eta^i}^2$, can vary by country. A value of δ^i smaller than unity implies market integration. For the momentum component of country i, we consider k possible lags of the growth rate of the country-specific component $x_{t-j}^i - x_{t-j-1}^i$ (j varying from 1 to k) with coefficients ρ_j^i presumed positive. If all ρ_j^i are estimated to equal *zero* then there is no momentum effect .

The definition of p_t^i as the log of the equity price index of country i with reinvested dividends implies that the continuously compounded return r_t^i is given as:

$$r_t^i = p_t^i - p_{t-1}^i . \tag{4}$$

Note that with enough countries i the assumption that η_t^i is cross-sectionally uncorrelated implies that it is reasonable to set the worldwide average of the country-specific components equal to zero,

$$x_t^w = 0, \quad r_t^w = \alpha_t \ . \tag{3b}$$

The second equality follows from the first given equations (1), (2), and (4).

Equations (1) - (3) supplemented by (4) represent an integrated mean reversion-momentum model. From these four equations it is straightforward to find the return in country i relative to the world return as:

$$r_t^i - r_t^w = -(1-\delta^i)(x_{t-1}^i - \mu^i) + \sum_{j=1}^{k} \rho_j^i (r_{t-j}^i - r_{t-j}^w) + \eta_t^i \ . \tag{5}$$

(b) Return Decomposition

To simplify notation we can write:

$$R_t^i = -(1-\delta^i) X_{t-1}^i + \rho^i(L) R_{t-1}^i + \eta_t^i \ , \tag{6}$$

where $R_t^i \equiv r_t^i - r_t^w$, $X_t^i \equiv x_t^i - \mu^i$, and $\rho^i(L) \equiv \sum_{j=1}^{k} \rho_j^i L^{j-1}$.

Or simply,

$$R_t^i = MRV_t^i + MOM_t^i + \eta_t^i \ , \tag{7}$$

with $MRV_t^i \equiv -(1-\delta^i) X_{t-1}^i$, $MOM_t^i \equiv \rho^i(L) R_{t-1}^i$.

The left-hand side of equation (7) represents the excess return for country index i (excess relative to the world mean return); in obvious notation, the first term on the right-hand side represents the mean reversion component of return and the second term on the right-hand side represents the momentum component. The unconditional expectation of the mean reversion term $E(MRV_t^i)$ is equal to zero [since $E(x_{t-1}^i) = \mu^i$ from equation (3a)] and, similarly, the unconditional expectation of the momentum component $E(MOM_t^i)$ is equal to zero. Hence, *average* excess returns R_t^i are zero and the realized country returns r_t^i can be cleanly decomposed into the global average return r_t^w, a mean reversion component, a momentum component, and an idiosyncratic shock component. The formulation is flexible, yielding the momentum formulation of Jegadeesh and Titman (1993) as a special case when $\delta^i = 1$ (for all i) and $\rho_j^i = \rho^i$ (for all i and j) and the mean reversion formulation of Balvers, Wu, and Gilliland (2000) as a special case when $\rho_j^i = 0$ (for all i and j).

In the empirical implementation we deviate in two additional ways from the Fama and French (1988) approach. First, as in Fama and French, we ignore the potential usefulness of earnings and other non-price information in forecasting future returns. The reason is that we do not have to specify fundamental values. Fama and French avoid this by first-differencing to remove the fundamental component, considering returns information instead of price information. As first-differencing is accompanied by a loss in information about slowly decaying processes (such as, typically, the mean reversion component) we deviate from Fama and French by not differencing the data and focusing on price information instead of returns information.[1]

The second deviation in the empirical implementation relative to Fama and French (1988) is that, while we use time series information to estimate parameters as do Fama and French, we take the additional step of assessing the usefulness of the parameter estimates in guiding portfolio switching strategies. That is, we employ the parameter estimates (using only past information) for investment decisions and evaluate the resulting excess returns. The focus on investment strategies designed to exploit mean reversion and momentum is similar to the DeBondt and Thaler (1985) approach designed to exploit mean reversion and the Jegadeesh and Titman (1993) approach to exploit momentum, with as major difference that these approaches are non-parametric whereas ours is explicitly parametric. For a similar parametric approach see Jegadeesh (1990) and, more recently, Balvers, Wu, and Gilliland (2000).

3. Panel Evidence for Market Integration

Monthly returns data are obtained from the MSCI equity market price indices for 18 countries with well-developed equity markets: Australia, Austria, Belgium, Canada, Denmark, France, Germany, Hong Kong, Italy, Japan, the Netherlands, Norway, Singapore, Spain, Sweden, Switzerland, the United Kingdom, and the United States. A value-weighted world index is also available. We use here the prices with reinvested gross dividends [that is, before withholding taxes, see Morgan Stanley Capital International (1997) for details] converted to dollar terms. The period covered is from the start of the data series, in December 1969, through December 1999. Table 1 shows the summary statistics, with average annualized monthly returns and standard deviations for each country and each country's beta with the world index return.

Table 2 reports the panel-test results for market integration for four panels of countries in our data set. We use two statistics to test for market integration: $z_\delta = T(1-\hat{\delta})$ and $t_\delta = (1-\hat{\delta})/s(\delta)$, where $\hat{\delta}$ is the panel OLS estimate, T is the number of time-series observations, and $s(\delta)$ is the standard deviation of $\hat{\delta}$. The null hypothesis of no market integration is $(\delta=1)$, while the alternative hypothesis of integration is $\delta<1$. As the test statistics do not follow standard normal distributions under the null hypothesis $(\delta=1)$, we generate critical values through Monte-Carlo simulation. The experiment is carried out as follows. Step 1: Simulate N independent random walk processes with T price observations each, where N is the number of countries in our panel. Step 2: Estimate the system with the simulated observations and calculate the two statistics, z_δ and t_δ. Step 3: Repeat steps 1 and 2 for a total of 5,000 times to produce the empirical distribution of the test statistics under the null of $\delta=1$. The p-values reported in Table 2 are defined as the percentage of the Monte-Carlo distribution having values greater than the corresponding historical test statistics computed with the data.

For the panel of all 18 countries relative to the world market, the speed of reversion (annualized) is 27.4% per year, and the null hypothesis of no market integration can be rejected at the 1% significance level based on the z_δ test and at the 5% level using the t_δ test. For 17 countries relative to the Hong Kong market, the null hypothesis of no integration can be rejected at the 5% level based on the z_δ test

1 For a recent approach that avoids first differencing while still utilizing earnings and cost of equity forecasts see Lee, Myers, and Swaminathan (1999).

and at the 10% level using the t_δ test. The speed of adjustment is 31.2% per year. When the U.S. market is used as a benchmark, the null can be rejected at the 1% level based on the z_δ test and at the 5% level using the t_δ test, with the speed of reversion of 29.2% per year. Finally, using a smaller panel of three Asian countries (Hong Kong, Japan and Singapore) plus the U.S. relative to the world market, we find that the null can be rejected at the 5% level using both tests and the annual speed of reversion is 28.3%.

While the above estimates of δ, which characterizes the speed at which equity indices revert to a benchmark value, are in general quite large, it should be pointed out that the point estimate of δ is biased and therefore the above results should be interpreted with caution. To correct for the small-sample bias of $\hat{\delta}$, we carry out a similar Monte-Carlo experiment. We first simulate N price series with T observations each, with a specific value of δ, and then obtain an estimate $\hat{\delta}$. Replicating this process for 1,000 times yields the empirical distribution of $\hat{\delta}$ under this particular value of δ. We conduct the experiment for various values of δ. Using interpolation, we estimate the values of δ that equate the median and the five and 95 per cent fractiles of the simulated $\hat{\delta}$'s to our historical $\hat{\delta}$. This yields the median-unbiased estimate of δ and its 90 per cent confidence interval, as reported in Table 2. We find that for the four panels considered, the unbiased estimate of speed of market integration ranges between 18% to 22% per year. These estimates imply a half-life of between 2.8 to 3.5 years.

Having established the strong evidence of market integration in the following section, we proceed to estimate separately the permanent and transitory components using maximum likelihood and to study implications of the two-component model.

4. Switching Strategy Returns

The estimation of the Fama-French model is conducted employing a maximum likelihood estimation procedure. The model parameters to be estimated, in principle, are the δ^i, the $\sigma^2_{\eta^i}$, the ρ^i_j, and the μ^i. This sums to a set of 18$(k+3)$ parameters, which is a high number in light of our 18 by 361 panel. Hence, to improve efficiency and avoid multicollinearity problems we set $\sigma^2_{\eta^i}$ for σ^2_η all i and, in most specifications, do one or more of the following: $\delta^i = \delta$, $\rho^i_j = \rho_j$, or $\rho^i_j = \rho^i$ (the μ^i are always allowed to differ by country as they allow for possible "mispricing" at the beginning of the sample period). Thus anywhere between 21 and 18$(k+2)$+1 parameters remain to be estimated.

The joint consideration of momentum and mean reversion urges us to use a parametric procedure for establishing the trading rules. We follow the parametric approach of Balvers, Wu, and Gilliland (2000) who consider a strategy for exploiting mean reversion results, using only prior information. Starting at $^1/_3$ of their sample, they use rolling parameter estimates to forecast expected returns for the upcoming period and then buy the fund with the highest expected return and short-sell the fund with the lowest expected return. We extend this strategy to exploit simultaneously the mean reversion and the momentum effects. Clearly, the "index" that combines the potential for mean reversion and momentum for each country is the conditional expected return. Accordingly, we employ a switching strategy of buying at each point in time the country index with the highest expected return, and/or short-selling the country index with the lowest expected return, based on equation (6) and using parameters estimated from prior data only. We start the forecast period at $^1/_3$ of the sample, in January 1980, and update parameter estimates as we roll the sample forward.

The empirical model of equation (5) will be applied with 12 possible momentum lags (which appears to be the highest momentum lag commonly found in the literature) and a one-month holding period (or until the latest available information induces a portfolio change) as the benchmark case. However, for the sake of comparison to existing approaches, we initially also consider pure momentum and mean reversion strategies and plausible variations of the combined momentum-mean reversion strategy. In Tables 3-5, we consider four special cases based on equation (5): the pure momentum model, the pure mean reversion model, a random walk model, and the simplest combination mean reversion-momentum model.

(a) Pure Momentum Strategies

We first replicate the momentum approach of Jegadeesh and Titman (1993) for our data set of national equity market indices. For our empirical model in equation (5) or (6) this is equivalent to setting $\delta^i = 1$ (for all i) and $\rho^i_j = \rho^i$ (for all i and j); thus (excess) realized returns over the previous J periods are weighted equally in determining expected future returns. The country index with the highest expected return (based fully on past momentum for this strategy) is chosen as the "Max1" portfolio and the country index with the lowest expected return is chosen as the "Min1" portfolio. The strategy of buying Max1 and shorting Min1 and holding this portfolio for K periods is referred to as "Max1-Min1" and listed under the appropriate value for K (similarly "Max3" and "Min3" refer to the strategies of holding the three country indices with, respectively, the highest and the lowest expected returns).

Jegadeesh and Titman (1993) focused only on the permutations of $J = 3, 6, 9, 12$ and $K = 3, 6, 9, 12$ which are shaded in Table 3. However, since our model is designed for forecasting returns one period (month) ahead, we also add the case of $K = 1$, in which the portfolio is held only until the updated return forecast is available. Additionally, we speculate that controlling for mean reversion as we do in our combination model of equation (5) is likely to imply a longer duration of the momentum effect (since positive momentum after, say, 12 months of previous momentum is likely to be offset by the downward pull of mean reversion and thus would not register in a pure momentum approach); accordingly, we also add the permutations for $J = 15, 18, 21, 24$ and $K = 15, 18, 21, 24$ in Table 3.

The results for the forecast period January 1980 - December 1999 (earlier data are reserved for parameter estimation as is needed for other strategies) are displayed in Table 3. These results generally agree, both quantitatively and qualitatively, with those of Jegadeesh and Titman (1993) for U.S. equities and those of Rouwenhorst (1998) and Chan, Hameed, and Tong (2000) for international equities. Returns (per dollar invested) for the Max1-Min1 and Max3-Min3 portfolios are positive for all cases originally considered by Jegadeesh and Titman (shaded) and, in the range most commonly considered, $J = 6, 9$ and $K = 6, 9,$ equal to around 10% annually and statistically significant for the Max3-Min3 cases. For the case of $K = 1$ returns are generally substantially lower and sometimes negative. As expected without controlling for mean reversion and consistent with Jegadeesh and Titman (2001), returns for longer holding periods $(K>12)$ fall rapidly as K increases to 24. Additionally, increasing the observation period J beyond 12 lowers returns substantially.

(b) Pure Mean Reversion and Random Walk Strategies

A further special case of equation (5) arises if we ignore momentum and focus on mean reversion only by setting $\rho^i_j = 0$ (for all i and j). The resulting formulation is equivalent to that used in Balvers, Wu, and Gilliland (2000) to detect mean reversion, employing an international sample similar to ours. Their approach requires employing all available (panel) data prior to the forecast period to estimate the mean reversion parameter. Hence, in contrast to the momentum case in Table 3, we cannot vary J but we can vary the holding period K as shown in Table 4. Again, the results are consistent with those of Balvers, Wu, and Gilliland and with the earlier work on contrarian strategies exploiting mean reversion by DeBondt and Thaler (1985, 1987) and others. The contrarian strategy returns are positive in all cases. For Max1-Min1 the returns rise with K to 11.1% at $K=6$ and then slowly drop with K to 7.5% for $K=24$. The returns for Max3-Min3 are lower, increasing slowly from 3.4% at $K=1$ to 5.6% at $K=15$ and then fall with K to 4.2% at $K=24$. These results correspond reasonably well to the results for annual data in Balvers, Wu, and Gilliland who find (for $K=12$) the Max1-Min1 return as 9.0% and the Max3-Min3 return as 8.4%.

Table 4 also shows the returns obtained with a pure "random walk" strategy. This case is obtained from equation (5) by ignoring all lagged price components. Accordingly, country indices are allowed to differ by mean return only. The random walk strategy then selects the country index with the highest expected return obtained by averaging return realizations prior to each forecast period. In a simple efficient markets view, those assets with the highest prior returns are likely to be riskiest and thus are expected to have the highest returns in the future, as argued by Conrad and Kaul (1988, 1998). Since all returns prior to the forecast period are used in obtaining the best estimate for expected return, J cannot vary (as is also the case for the mean reversion case). Table 4 reveals that this strategy produces negative returns for all K. Clearly, this is an unexpected result given a standard efficient markets perspective, but can be understood easily from a mean reversion perspective, as in this view higher past realized returns are likely to indicate that future returns will be lower as equity prices return to trend.

(c) Combination Momentum and Mean Reversion Strategies

We now present the returns obtained (out of sample) by following a strategy that, based on equation (5), combines the potential for mean reversion and momentum into one index for each asset, and chooses for each period the asset with the highest expected return (Max1) and shorts the asset with the lowest expected return (Min1). Equation (5) allows for eight basic ways of combining the potential for momentum and mean reversion into one index, depending on whether the momentum parameters are allowed to differ by country and/or are allowed to differ by lag and whether the mean reversion parameter is allowed to differ by country. We take here as our benchmark the most parsimonious case that encompasses both the pure momentum and mean reversion cases, namely the case of one momentum parameter ($\rho^i_j = \rho$ for all i, and j) and one mean reversion parameter ($\delta^i = \delta$ for all i). The returns for the seven alternative ways of combining momentum and mean reversion will be discussed in a robustness section.

Table 5 displays the combination strategy returns based on equation (5) with one momentum parameter and one mean reversion parameter. Returns are positive in all cases. For easy comparison with the pure momentum case that was considered for the same permutations of K and L, the specific instance in which the combination strategy outperforms the pure momentum strategy are shaded in Table 5. There are 72 permutations of K and L. In 72 of 72 Max1-Min1 strategies and in 67 of 72 Max3-Min3 strategies, the combination strategy outperforms the pure momentum strategy. The Max3-Min3 cases where the momentum strategy works somewhat better are for J=6 and 9 and K smaller or equal to 6. For the 16 cases considered by Jegadeesh and Titman (1993), shaded in Table 3, the average of the pure momentum return for Max1-Min1 is 6.65% and for Max3-Min3 is 7.30%, while for these 16 cases the average combination strategy return for Max1-Min1 is 11.05% and for Max3-Min3 is 8.84%.

Comparing the combination strategy return against the pure mean reversion return is more difficult since J does not vary in the mean reversion case. Taking the average for the K=3, 6, 9, 12 cases considered in Jegadeesh and Titman produces a Max1-Min1 return of 10.30%, only slightly lower than in the combination strategy case, but a Max3-Min3 return of 4.40%, less than half of the combination strategy return.

The most relevant comparison, however, may be the comparison for the case of K=1; since the optimal forecast is updated each month, the most reasonable strategy for maximizing excess returns is one where the portfolio, in principle, is adjusted each time when a new forecast is available. Under this criterion, the Max1-Min1 return is 2.83% under pure momentum, 8.50% under pure mean reversion, and 12.25% under the combination strategy; the Max3-Min3 return is 9.03% under pure momentum, 3.4% under pure mean reversion, and 9.03% under the combination strategy. In the following, we will use as the benchmark case the natural case of K=1 and we will set J=12 to allow, in principle, for 12 possible momentum lags. In this instance, the Max1-Min1 return is 9.5% under pure momentum, 8.50% under pure mean reversion, and 16.70% under the combination strategy; the Max3-Min3 return is 11.20% under pure momentum, 3.4% under pure mean reversion, and 11.90% under the combination strategy.

5. Robustness of Results

(a) Returns to Plausible Variations in Strategies

Panel A in Table 6 first summarizes again, as Models 1-4, the returns for the basic strategies (combination, pure momentum, pure mean reversion and random walk) for the benchmark case of a one-month holding period and 12 momentum lags if applicable (K=1, J=12); also listing the world market beta, expected return, and percentage of portfolio switched each period. We use this information later on to discuss risk, robustness, and transaction costs. As in Balvers, Wu, and Gilliland (2000), to provide a sense of proportion, we present the perfect foresight strategy results (Model 5, the *ex post* optimal choices) and the results of the benchmark strategy employing full sample parameters (Model 6, in-sample optimal choices). As expected, returns for Model 5 are dramatically higher (Max1-Min1 return is 227.5%), and returns for Model 6 are significantly higher (Max1-Min1 return is 32.2%) compared to the benchmark combination strategy return (Max1-Min1 return is 16.7%).

Model 7 in Panel A reports the returns to the benchmark combination strategy when the momentum parameters may vary across lags, and the 24 momentum lags are restricted by 4 Almon lag parameters. In this case, returns continue to be positive, but not significantly so for the Max1-Min1 strategy. The extension to 24 lags is useful as it is no longer clear, after controlling for mean reversion, if 12 momentum lags is enough; the results confirm those in Table 5 that adding momentum lags beyond 12 does not increase expected returns.

Models 8 and 9 in Panel A give the returns on the benchmark combination strategy when the starting point varies. Model 8 presents the results when forecasts start at $^1/_4$ of the sample so that there are more sample points but obtained from less precise parameter estimates. Returns are slightly higher compared to the benchmark case starting at $^1/_3$ of the sample. Model 9 presents the results when forecasts start at $^1/_2$ of the sample so that there are fewer sample points but obtained from more precise parameter estimates. Returns now are slightly lower compared to the benchmark case.

The benchmark combination strategy is the simplest strategy allowing combination of momentum and mean reversion. Panel B in Table 6 presents the returns of all other basic variations to the combination strategy presented by equation (5). Specifications differ by whether or not the momentum parameter varies across countries and/or lags, and whether the mean reversion parameter varies across countries. Model 1 in Panel B presents again the returns for the benchmark case for reference. In all cases the returns are significantly positive (although only at the 10% level for the Max1-Min1 returns for Models 6 and 7). Three of the seven variations outperform the benchmark on the Max1-Min1 strategy and two of the seven variations outperform the benchmark on the Max3-Min3 strategy. In general, allowing mean reversion parameters to differ across countries (in Models 5-8) lowers returns, while allowing momentum parameters to vary across countries and lags improves returns. The highest returns occur in Model 4 with one mean reversion parameter and 12x18 momentum parameters. Here the Max1-Min1 return is 20.3% and the Max3-Min3 return is 14.3%.

Figure 1 provides additional information about the robustness of the combination strategies in Panel B. Instead of focusing only on the one or three countries with the highest expected returns and the one or three countries with the lowest expected returns, Figure 1 ranks 18 strategies: Max(i) represents the strategy of investing each period in the country index with the ith highest expected return. Thus Return[Max(1)] is identical to Return[Max1] and Return[Max(1)] + Return[Max(2)] + Return[Max(3)] = 3 Return[Max3]. Figure 1 displays strategies Max(i) for i from 1 to 18 on the horizontal axis and Return[Max(i)] on the vertical axis. The slope of the regression line is clearly negative for all combination strategies in Panel B.

(b) Expected Returns

The expected returns in Table 6 are generated, based on equation (5), by employing the parameter estimates that apply at each point to calculate the expected return for an out-of-sample point, and then averaging over all out-of-sample points. This expected return can thus be interpreted as the expected return that would be generated for a given model by the switching strategy applied over the out-of-sample period, under the assumption that the model is exactly correct – no omitted variables, no nonlinearities, and perfect parameter estimates. This expected return measure is useful as an indicator of what mean return can maximally be expected from the switching strategies based on a particular model specification. The expected return in the base case (Model 1 in Panels A and B) equals 39.3% for Max1-Min1 and 36.7% for Max3-Min3. Thus, *realized* returns are, respectively, 42.5% and 32.4% of what would be expected based on the employed model being correct. Given our limited time series, these percentages could reasonably be anticipated, even if the model were correctly specified, based on imperfect parameter estimates alone. Expected returns for the more restrictive model specifications in Panel A (Models 2, 3, and 4) are lower as might be expected because less variation in country-specific anticipated returns is generated.

While in general the realized returns are clearly lower than the expected returns, the expected return in the case of full sample estimates (Model 6) is approximately equal to the realized return. Two possibilities readily present themselves to explain this: the model is very well specified so that, with good, full sample, parameter estimates the realized return deviates from the expected return only stochastically and should on average equal this realized return; or, the full sample estimation procedure uses sufficient information not available in real time to offset the drawback of an imperfectly specified model and lead to expected returns similar to those expected for a perfectly specified model.

Expected returns in Panel B are similar for all variants except for the variants with varying momentum parameters across countries and lags, Models 4 and 8, where they are about double the expected returns in the other cases. This feature seems to explain why these models produce higher expected returns.

(c) Transaction Costs

We also present in Table 6 the number of portfolio switches implied by each investment strategy. This allows us to assess transaction costs, which are likely to be substantial for monthly switching. Carhart (1997) points out for instance that for mutual funds following momentum investment strategies the excess returns disappear when transactions costs are considered; Grundy and Martin (2001) conclude similarly for U.S. equities. In the cases of Max3 and Max3-Min3 we count each switch of one of the three or six country indices for $^1/_3$ and $^1/_6$ of a switch, respectively. A switch entails selling one country index and purchasing another. There is therefore a round-trip transactions cost in the form of a brokerage cost. In addition, there is a loss in the form of the bid-ask spread. Both together may vary from around 1% to 2% per switch, depending on the time period, the countries involved, and whether short-selling is involved. See for instance McGuinness (1999, pp. 75-6). The last column of Panel A in Table 6 indicates that the momentum aspect of the full model accounts for a large percentage of the switches. The percentage of the portfolio switched in each period is 39% for the pure momentum model and falls from 16% for the benchmark combination model to 11% for the pure mean reversion model (all for the Max1-Min1 strategies).

If no adjustment to the strategies were made then the transactions costs might negate a significant part of the excess returns generated by our portfolio switching strategies. For instance, in Model 1, the Max3-Min3 strategy requires a switch 11% of the time, or 1.32 times per annum multiplied by two since switches occur in both Max3 and Min3. At a cost per switch of 2% the resulting transactions costs of 5.3% would offset nearly half of the excess return of 11.9%. Note by the way that, as Grundy and Martin (2001) point out, establishing that one cannot profit from momentum does not imply that momentum disappears; it is still a feature of financial markets.

Once transaction costs are considered it is clearly not optimal to switch portfolios the moment the expected return of one country index exceeds the expected return of the currently-held country index. We assume here that the expected returns differential must at least exceed the transaction cost (we assume 1%) before a switch occurs.[2] Table 7 shows the returns resulting from superimposing a transaction cost filter on the switching strategies: in each of the model specifications a switch occurs only if the expected return of the best alternative country index is at least 1% higher than the expected return of the country index currently held.

The addition of the filter produces very little change in the expected returns, but the percentage switches falls dramatically. Thus, for this 1% filter, the expected return for the Max3-Min3 strategy in the benchmark combination model equals 26.9% (instead of 36.7% without the transactions cost filter); switches occur only 2% (instead of 10% without the transactions cost filter) of the time so that annual transactions costs equal 12x2x0.02x1% = 0.48%, leaving an excess return after transactions costs of 10.32%. One way of interpreting this result is that the estimation of the momentum parameters is sufficiently imprecise, so that the substantial reduction in the number of transactions is clearly worth the cost of ignoring small differences.

(d) Global Risk Factors

Standard equilibrium risk factors should apply if the developed markets examined here can be considered as integrated. First, consider the conventional single market-beta model. In our global context, a country-index market beta is obtained based on the world portfolio return, as proxied by the MSCI value-weighted world index return. Assuming that relative purchasing power parity provides a decent description of reality, the world market beta of each portfolio should fully explain cross-sectional average return discrepancies.[3] Column 5 of Table 6 lists the beta of each trading strategy based on covariance with the world portfolio return. The betas for the excess returns strategies, Max1-Min1 and Max3-Min3 are negative in the relevant cases, implying that world-beta-risk-adjusted excess returns are in fact higher than the original excess returns.

Table 8 presents two-factor risk-adjusted return results for the benchmark model (combined momentum and mean reversion), the pure momentum model, and the pure mean reversion model. The specification of the two-factor model follows Fama and French (1998). Results are obtained by regressing the monthly returns of the various Max and Min portfolios on the excess return on the MSCI world index and the excess return on an internationally diversified portfolio long on value and short on growth stocks. The estimated constant terms are the “alphas”–the risk-adjusted returns. Both the Max1-Min1 and the Max3-Min3 portfolios have negative exposure to world market risk but (moderately) positive exposure to value risk. In all cases, the risk-adjusted returns are similar to the raw returns. In particular, the risk-adjusted benchmark returns continue to be large and significant: 18.6% for Max1-Min1 and 11.9% for Max3-Min3, both significant at the 1% level. Observe that the positive alphas result mostly from the Min1 part

2 This strategy is not exactly optimal as, for instance, an expected returns differential of 0.6% may be expected to last more than one period, thus exceeding in expectation a 1.0% transaction cost. However, if anything, this non-optimality biases our results against finding significant excess returns net of transaction costs.

3 For validity of long-run purchasing power parity, see, e.g., Wu (1996).

of the zero-investment strategy. The risk-adjusted returns for the pure momentum and pure mean reversion models are insignificant. These results are roughly consistent with the Fama and French (1996) conclusion that mean-reversion effects can be explained as factor risk but the momentum effects cannot.

6. Conclusion

The purpose of this paper has been to study market integration and return forecastability among developed equity markets. Our panel methodology greatly increases the power of the test for integration. We find significant evidence of integration among 18 national equity markets. Motivated by the two-component model of Fama and French (1988), we decompose a country's stock index price into a world common component and a country-specific transitory component. Our results show that the 18 country indexes reverse to the world trend with a speed of 18% per year, and that the Hong Kong market converges to other markets with a speed of 22% per year, implying a half life of around three years.

We then study the implications of the two-component model. We find that the country-specific component displays substantial variability and has both mean reversion over the long horizon and momentum over the short horizon. A simple trading strategy that draws on the combined promise for momentum and mean reversion in 18 national market stock indexes, produces significant excess returns. Specifically, investing in the national market with the highest index number and short-selling the national market with the lowest index number generates an annual excess return of 16.7% over the 20-year "out-of-sample" period 1980-1999. The excess return in the joined momentum/mean reversion model is higher than the excess returns found in either of the separate momentum or mean reversion models. Our results are robust to several alternative specifications and to reasonable transaction costs. Furthermore, the excess returns cannot be interpreted as compensations for bearing more systematic risks.

Our results thus provide additional evidence for the existence of mean reversion and momentum. The simultaneous existence of both effects points at the validity of the overreaction hypothesis. Naturally, one may provide efficient markets explanations, but these are likely to be less parsimonious than the overreaction perspective. Of course, the overreaction hypothesis is inadequate as a complete theory since it does not specify, for instance, what would occur if the expected returns pattern described here and in other work becomes widely accepted. In an efficient markets explanation, revealing the expected returns pattern should make no difference for the future path of expected returns; in a quasi-rational view such as the overreaction hypothesis represents, an explicit choice-theoretic basis is needed to predict public reaction to the uncovered profit opportunities. The work by Barberis, Shleifer, and Vishny (1998), Daniel, Hirshleifer, and Subrahmanyam (1998), and Hong and Stein (1999) has already made important strides in that direction.

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Table 1: Summary Statistics of National Stock-Index Returns

This table reports summary statistics for return data from Morgan Stanley Capital International over the period 1970:1 to 1999:12. The mean returns and standard errors are annualized. In computing the betas, the U.S. treasury-bill rate is used as the risk-free rate of return.

Country	Mean	Standard Error	β with World Index
AUSTRALIA	0.084	0.904	1.049
AUSTRIA	0.095	0.720	0.501
BELGIUM	0.147	0.639	0.808
CANADA	0.103	0.664	0.969
DENMARK	0.136	0.640	0.646
FRANCE	0.129	0.794	1.019
GERMANY	0.124	0.707	0.841
HONG KONG	0.180	1.348	1.262
ITALY	0.077	0.903	0.814
JAPAN	0.135	0.783	1.075
NETHERLANDS	0.155	0.613	0.922
NORWAY	0.113	0.942	1.001
SINGAPORE	0.134	1.048	1.189
SPAIN	0.106	0.783	0.823
SWEDEN	0.166	0.767	0.906
SWITZERLAND	0.132	0.654	0.903
UNITED KINGDOM	0.130	0.799	1.105
UNITED STATES	0.126	0.530	0.898
WORLD	0.121	0.495	1.000

Table 2: Panel Tests for Market Integration of International Stock Prices

This table presents panel-based tests for stock market integration. The speed of reversion is measured by 1-δ. The test statistics $z_\delta = T(1-\hat{\delta})$ and $t_\delta = (1-\hat{\delta})/s(\delta)$ do not follow standard distributions and their p-values are computed from 5,000 Monte-Carlo replications. The small-sample bias under the alternative hypothesis that δ<1, as well as its 90% confidence interval are also estimated from Monte-Carlo simulation with 5,000 replications.

	Relative to World	Relative to Hong Kong	Relative to U.S.	Asia + US Relative to World
Speed of reversion 1-δ (annualized)	0.274	0.312	0.292	0.283
z_δ	7.407	8.434	7.894	7.632
p-value	0.002	0.015	0.000	0.022
t_δ	11.431	11.151	11.277	5.235
p-value	0.044	0.077	0.022	0.011
Median-Unbiased Estimate of (1-δ)	0.182	0.222	0.202	0.193
90% Confidence Interval of (1-δ)	[0.110, 0.250]	[0.155, 0.290]	[0.135, 0.270]	[0.124, 0.261]
Implied Half-Life (Years)	3.5	2.80	3.1	3.2

Table 3: Performance of Portfolio Switching Strategies: Pure Momentum Approach

This table reports the mean returns (annualized) of Max1, Max1-Min1, Max3 and Max3-Min3 portfolios formed by the Jegadeesh and Titman (1993) momentum strategy. The shaded areas (*J*=3,6,9,12; *K*=3,6,9,12) are the combinations of *J* and *K* originally examined by Jegadeesh and Titman (1993) for U.S. stock data.

	K=1		*K*=3		*K*=6		*K*=9		*K*=12		*K*=15		*K*=18		*K*=21		*K*=24	
	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio
J=3																		
Max1	0.192	3.316	0.165	3.301	0.176	3.802	0.171	3.873	0.158	3.589	0.142	3.470	0.133	3.376	0.137	3.650	0.124	3.424
Max1-Min1	-0.004	-0.056	0.038	0.650	0.070	1.418	0.080	1.903	0.065	1.670	0.023	0.663	0.005	0.171	0.015	0.525	-0.010	-0.372
Max3	0.164	3.637	0.158	3.781	0.155	3.803	0.159	4.109	0.153	3.867	0.135	3.590	0.142	3.858	0.142	3.973	0.135	3.894
Max3-Min3	0.025	0.558	0.034	0.889	0.045	1.367	0.058	2.136	0.046	1.795	0.013	0.564	0.013	0.578	0.014	0.722	0.007	0.401
J=6																		
Max1	0.171	2.687	0.206	3.647	0.188	3.729	0.175	3.545	0.148	3.063	0.131	2.985	0.138	3.316	0.134	3.330	0.125	3.225
Max1-Min1	-0.011	-0.137	0.056	0.803	0.084	1.478	0.093	1.827	0.050	1.045	0.008	0.180	0.010	0.272	0.012	0.336	-0.002	-0.064
Max3	0.211	4.528	0.216	4.844	0.195	4.629	0.177	4.159	0.156	3.749	0.147	3.732	0.146	3.883	0.144	3.956	0.140	3.983
Max3-Min3	0.116	2.290	0.103	2.363	0.106	2.864	0.090	2.573	0.050	1.543	0.026	0.870	0.023	0.865	0.022	0.911	0.022	1.016
J=9																		
Max1	0.141	2.228	0.180	3.110	0.161	2.879	0.138	2.577	0.125	2.549	0.124	2.739	0.129	3.031	0.129	3.120	0.122	3.059
Max1-Min1	0.033	0.418	0.101	1.449	0.112	1.763	0.078	1.333	0.035	0.656	0.013	0.273	0.016	0.366	0.011	0.268	-0.003	-0.075
Max3	0.198	3.901	0.189	3.990	0.173	3.801	0.158	3.592	0.146	3.504	0.141	3.606	0.145	3.881	0.141	3.908	0.135	3.872
Max3-Min3	0.108	2.126	0.118	2.594	0.113	2.675	0.082	2.081	0.046	1.292	0.032	0.991	0.028	0.971	0.023	0.881	0.017	0.752
J=12																		
Max1	0.184	2.583	0.180	2.838	0.140	2.384	0.135	2.547	0.131	2.625	0.131	2.799	0.141	3.133	0.134	3.088	0.120	2.917
Max1-Min1	0.095	1.107	0.092	1.234	0.049	0.753	0.041	0.714	0.020	0.382	0.000	0.002	0.007	0.167	0.001	0.028	-0.021	0.586
Max3	0.177	3.374	0.184	3.706	0.163	3.536	0.146	3.339	0.139	3.394	0.138	3.539	0.139	3.735	0.138	3.849	0.134	3.836
Max3-Min3	0.112	2.110	0.112	2.266	0.082	1.857	0.055	1.365	0.028	0.758	0.017	0.529	0.013	0.443	0.012	0.446	0.006	0.270

Table 3: Performance of Portfolio Switching Strategies: Pure Momentum Approach (continued)

	K=1		*K*=3		*K*=6		*K*=9		*K*=12		*K*=15		*K*=18		*K*=21		*K*=24	
	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio
J=15																		
Max1	0.113	1.636	0.112	1.824	0.159	2.892	0.152	2.900	0.140	2.799	0.136	2.845	0.135	2.960	0.131	2.964	0.120	2.824
Max1-Min1	-0.016	-0.199	-0.009	-0.118	0.042	0.668	0.032	0.565	0.017	0.321	-0.004	-0.075	-0.007	-0.149	-0.013	-0.314	-0.023	-0.594
Max3	0.149	2.807	0.159	3.380	0.144	3.231	0.137	3.280	0.136	3.377	0.137	3.570	0.141	3.840	0.140	3.969	0.136	3.940
Max3-Min3	0.052	0.966	0.051	1.056	0.043	0.998	0.030	0.769	0.016	0.440	0.009	0.292	0.010	0.330	0.008	0.286	0.004	0.180
J=18																		
Max1	0.122	1.718	0.168	2.847	0.164	2.955	0.154	2.826	0.142	2.737	0.140	2.841	0.136	2.877	0.124	2.740	0.115	2.628
Max1-Min1	-0.027	-0.341	0.056	0.825	0.044	0.712	0.040	0.670	0.008	0.142	0.001	0.013	-0.010	-0.202	-0.022	-0.487	-0.029	-0.676
Max3	0.140	2.650	0.150	3.356	0.141	3.377	0.135	3.354	0.133	3.396	0.134	3.585	0.135	3.767	0.135	3.888	0.130	3.845
Max3-Min3	0.030	0.573	0.037	0.827	0.033	0.816	0.018	0.467	0.005	0.129	0.001	0.023	-0.002	-0.054	-0.001	-0.044	-0.005	-0.200
J=21																		
Max1	0.149	2.279	0.164	2.743	0.147	2.588	0.139	2.518	0.135	2.559	0.121	2.447	0.111	2.367	0.106	2.371	0.101	2.315
Max1-Min1	0.045	0.564	0.051	0.733	0.050	0.760	0.033	0.522	0.017	0.289	-0.005	-0.089	-0.021	-0.415	-0.025	-0.509	-0.031	-0.667
Max3	0.145	3.116	0.155	3.659	0.140	3.475	0.136	3.469	0.139	3.607	0.134	3.641	0.138	3.854	0.133	3.850	0.127	3.777
Max3-Min3	0.013	0.276	0.036	0.854	0.030	0.763	0.017	0.451	0.007	0.210	-0.004	-0.134	-0.004	-0.130	-0.008	-0.290	-0.010	-0.406
J=24																		
Max1	0.154	2.419	0.149	2.505	0.134	2.335	0.125	2.266	0.121	2.288	0.102	2.081	0.099	2.124	0.099	2.205	0.099	2.278
Max1-Min1	0.029	0.379	0.032	0.445	0.011	0.171	-0.001	-0.009	-0.007	-0.110	-0.035	-0.620	-0.040	-0.743	-0.043	-0.848	-0.036	-0.733
Max3	0.142	3.177	0.144	3.534	0.128	3.188	0.128	3.273	0.125	3.260	0.122	3.304	0.128	3.586	0.125	3.636	0.120	3.554
Max3-Min3	0.028	0.628	0.021	0.513	0.002	0.062	-0.002	-0.067	-0.016	-0.459	-0.022	-0.694	-0.018	-0.621	-0.020	-0.735	-0.022	-0.843

Table 4: Performance of Portfolio Switching Strategies: Pure Mean Reversion and Pure Random Walk Approaches

This table reports the mean returns (annualized) of Max1, Max1-Min1, Max3 and Max3-Min3 portfolios. The portfolios are formed by assuming that either equity prices follow a pure random walk, or a pure mean reversion process.

	K=1		*K*=3		*K*=6		*K*=9		*K*=12		*K*=15		*K*=18		*K*=21		*K*=24	
	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio
Pure mean reversion																		
Max1	0.198	3.983	0.209	4.490	0.211	4.442	0.202	4.179	0.194	4.115	0.187	4.103	0.182	4.097	0.172	3.943	0.166	3.830
Max1-Min1	0.085	1.248	0.086	1.434	0.111	1.946	0.110	2.008	0.106	2.034	0.103	2.104	0.092	1.966	0.083	1.820	0.075	1.729
Max3	0.153	3.945	0.158	4.211	0.155	4.259	0.157	4.322	0.160	4.450	0.168	4.679	0.168	4.672	0.166	4.613	0.166	4.698
Max3-Min3	0.034	0.902	0.035	0.996	0.043	1.297	0.048	1.522	0.050	1.641	0.056	1.913	0.048	1.666	0.040	1.455	0.042	1.576
Pure random walk																		
Max1	0.141	2.077	0.130	1.939	0.104	1.574	0.089	1.355	0.084	1.316	0.077	1.243	0.074	1.239	0.077	1.336	0.074	1.302
Max1-Min1	-0.043	-0.580	-0.064	-0.860	-0.088	-1.199	-0.091	-1.255	-0.088	-1.235	-0.093	-1.336	-0.094	-1.378	-0.089	-1.328	-0.092	-1.411
Max3	0.115	2.402	0.124	2.657	0.111	2.429	0.102	2.296	0.099	2.273	0.102	2.401	0.112	2.693	0.115	2.833	0.114	2.843
Max3-Min3	-0.028	-0.776	-0.022	-0.604	-0.029	-0.815	-0.033	-0.938	-0.036	-1.048	-0.035	-1.059	-0.029	-0.896	-0.027	-0.849	-0.028	-0.867

Table 5: Performance of Portfolio Switching Strategies: Momentum with Mean Reversion

This table reports the mean returns (annualized) of Max1, Max1-Min1, Max3 and Max3-Min3 portfolios. The portfolios are formed by assuming that equity prices have both momentum and mean reversion effects. Numbers shaded indicate that the current strategy beats the Jagadeesh-Titman's pure momentum strategy.

	K=1		*K*=3		*K*=6		*K*=9		*K*=12		*K*=15		*K*=18		*K*=21		*K*=24	
	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio
J=3																		
Max1	0.233	4.637	0.201	4.239	0.190	3.892	0.183	3.982	0.179	3.987	0.171	3.867	0.167	3.849	0.169	4.005	0.164	3.979
Max1-Min1	0.094	1.464	0.074	1.305	0.103	1.917	0.109	2.202	0.117	2.493	0.098	2.211	0.088	2.024	0.083	2.026	0.073	1.861
Max3	0.187	4.662	0.181	4.697	0.179	4.636	0.180	4.735	0.185	4.754	0.175	4.528	0.170	4.474	0.170	4.593	0.168	4.615
Max3-Min3	0.079	2.165	0.066	1.993	0.080	2.497	0.090	2.885	0.087	2.797	0.070	2.361	0.058	2.016	0.055	2.029	0.048	1.797
J=6																		
Max1	0.162	2.868	0.185	3.347	0.169	3.319	0.170	3.431	0.161	3.341	0.153	3.242	0.153	3.367	0.153	3.499	0.156	3.633
Max1-Min1	0.061	0.945	0.079	1.310	0.095	1.743	0.108	2.130	0.096	1.996	0.084	1.790	0.074	1.681	0.073	1.766	0.074	1.891
Max3	0.176	4.366	0.177	4.405	0.180	4.510	0.186	4.622	0.175	4.383	0.170	4.310	0.170	4.403	0.168	4.513	0.168	4.622
Max3-Min3	0.062	1.726	0.067	1.927	0.094	2.730	0.097	2.847	0.075	2.284	0.061	1.950	0.056	1.875	0.048	1.674	0.048	1.734
J=9																		
Max1	0.179	3.244	0.165	3.203	0.161	3.200	0.152	3.092	0.139	2.877	0.125	2.725	0.129	2.899	0.140	3.241	0.158	3.758
Max1-Min1	0.168	2.562	0.143	2.363	0.146	2.660	0.124	2.367	0.089	1.747	0.068	1.403	0.051	1.083	0.053	1.175	0.063	1.487
Max3	0.195	4.671	0.201	4.854	0.201	4.792	0.183	4.429	0.170	4.219	0.163	4.158	0.164	4.344	0.166	4.515	0.165	4.592
Max3-Min3	0.101	2.707	0.113	3.021	0.121	3.325	0.092	2.639	0.067	2.026	0.054	1.676	0.049	1.605	0.049	1.681	0.047	1.678
J=12																		
Max1	0.180	3.401	0.177	3.450	0.159	3.187	0.153	3.091	0.143	3.095	0.128	2.859	0.134	3.108	0.150	3.533	0.152	3.655
Max1-Min1	0.167	2.449	0.156	2.540	0.130	2.278	0.106	1.890	0.093	1.789	0.066	1.310	0.062	1.256	0.077	1.649	0.074	1.649
Max3	0.203	4.528	0.216	4.958	0.190	4.545	0.173	4.240	0.163	4.072	0.155	4.033	0.161	4.313	0.163	4.494	0.160	4.490
Max3-Min3	0.119	2.964	0.121	3.152	0.102	2.797	0.079	2.288	0.063	1.906	0.048	1.478	0.047	1.530	0.047	1.565	0.042	1.469

Table 5: Performance of Portfolio Switching Strategies: Momentum with Mean Reversion (continued)

	K=1		*K*=3		*K*=6		*K*=9		*K*=12		*K*=15		*K*=18		*K*=21		*K*=24	
	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio	Mean Return	*t*-ratio
J=15																		
Max1	0.166	3.197	0.164	3.206	0.150	2.949	0.148	3.001	0.146	3.064	0.136	2.911	0.157	3.417	0.150	3.329	0.166	3.678
Max1-Min1	0.083	1.423	0.074	1.362	0.087	1.620	0.093	1.856	0.094	1.952	0.077	1.640	0.100	2.179	0.087	1.947	0.099	2.250
Max3	0.217	5.359	0.203	5.255	0.183	4.741	0.174	4.553	0.166	4.433	0.162	4.382	0.168	4.666	0.167	4.781	0.160	4.628
Max3-Min3	0.111	3.070	0.082	2.449	0.069	2.045	0.064	1.951	0.052	1.610	0.047	1.510	0.051	1.708	0.048	1.679	0.040	1.415
J=18																		
Max1	0.157	2.970	0.159	3.065	0.154	3.125	0.154	3.218	0.151	3.215	0.154	3.355	0.154	3.430	0.157	3.520	0.160	3.628
Max1-Min1	0.052	0.876	0.074	1.297	0.081	1.519	0.083	1.617	0.080	1.656	0.086	1.829	0.087	1.872	0.084	1.885	0.089	2.056
Max3	0.184	4.602	0.186	4.845	0.178	4.705	0.173	4.629	0.170	4.551	0.172	4.740	0.174	4.835	0.171	4.817	0.165	4.690
Max3-Min3	0.061	1.784	0.062	1.891	0.064	2.058	0.062	2.007	0.059	1.939	0.064	2.151	0.063	2.135	0.056	1.938	0.048	1.718
J=21																		
Max1	0.158	2.989	0.157	3.122	0.157	3.292	0.153	3.259	0.155	3.358	0.151	3.352	0.155	3.478	0.158	3.581	0.162	3.706
Max1-Min1	0.069	1.166	0.063	1.140	0.063	1.174	0.068	1.335	0.079	1.615	0.082	1.740	0.088	1.898	0.093	2.066	0.101	2.299
Max3	0.197	4.853	0.193	5.047	0.178	4.822	0.172	4.689	0.174	4.762	0.172	4.758	0.171	4.812	0.167	4.729	0.163	4.670
Max3-Min3	0.080	2.301	0.061	1.847	0.057	1.811	0.059	1.886	0.066	2.137	0.061	2.022	0.057	1.952	0.051	1.770	0.046	1.652
J=24																		
Max1	0.156	2.941	0.160	3.246	0.157	3.345	0.165	3.591	0.156	3.478	0.157	3.535	0.159	3.605	0.159	3.660	0.166	3.829
Max1-Min1	0.047	0.770	0.048	0.866	0.065	1.232	0.080	1.563	0.075	1.529	0.084	1.795	0.086	1.887	0.090	2.014	0.102	2.327
Max3	0.192	4.812	0.193	5.076	0.186	5.025	0.179	4.883	0.178	4.912	0.179	4.945	0.175	4.898	0.168	4.784	0.166	4.740
Max3-Min3	0.078	2.152	0.066	1.921	0.067	2.044	0.073	2.296	0.069	2.217	0.072	2.434	0.062	2.168	0.052	1.866	0.047	1.709

Table 6: Comparison of Model Performance

Panel A. 1) Baseline model where the mean reversion parameter is the same for all countries, and the momentum parameter is the same for all lags and countries; 2) Jegadeesh-Titman pure momentum; 3) Pure mean reversion; 4) Pure random walk; 5) Perfect foresight; 6) Baseline model with full-sample parameter estimates; 7) 24-month momentum with mean reversion. The 24 momentum lags are constrained with 4 Almon lags, but each lag parameter is the same for all countries, and the mean reversion parameter is the same for all countries; 8) Baseline model with forecast starting at $^1/_4$ of sample; and 9) Baseline model with forecast starting at $^1/_2$ of sample.

Model	Portfolio	Mean Return	*t*-ratio	β with World Portfolio	Expected Return	Percentage Switches in Portfolio
1	Max1	0.180	3.401	0.962	0.318	0.13
	Max1-Min1	0.167	2.449	-0.301	0.393	0.16
	Max3	0.203	4.528	0.984	0.260	0.10
	Max3-Min3	0.119	2.964	-0.064	0.367	0.10
2	Max1	0.184	2.583	1.284	0.212	0.35
	Max1-Min1	0.095	1.107	0.373	0.151	0.39
	Max3	0.177	3.374	0.154	0.191	0.25
	Max3-Min3	0.112	2.110	0.297	0.130	0.26
3	Max1	0.198	3.983	0.615	0.241	0.11
	Max1-Min1	0.085	1.248	-0.621	0.218	0.11
	Max3	0.153	3.945	0.837	0.212	0.10
	Max3-Min3	0.034	0.902	-0.245	0.198	0.09
4	Max1	0.141	2.077	1.284	0.238	0.03
	Max1-Min1	-0.043	-0.580	0.434	0.154	0.04
	Max3	0.115	2.402	1.177	0.216	0.05
	Max3-Min3	-0.028	-0.776	0.240	0.115	0.03
5	Max1	1.284	28.304	0.920	1.284	0.88
	Max1-Min1	2.275	45.572	-0.310	2.275	0.86
	Max3	0.979	25.356	0.924	0.979	0.78
	Max3-Min3	1.667	44.330	-0.201	1.667	0.79
6	Max1	0.277	4.991	1.134	0.263	0.20
	Max1-Min1	0.322	5.046	0.090	0.284	0.16
	Max3	0.230	4.816	1.078	0.232	0.12
	Max3-Min3	0.202	4.754	0.100	0.211	0.14
7	Max1	0.165	3.071	0.992	0.354	0.02
	Max1-Min1	0.105	1.638	-0.199	0.476	0.05
	Max3	0.218	5.268	0.917	0.275	0.06
	Max3-Min3	0.115	3.246	-0.117	0.355	0.06
8	Max1	0.212	4.164	0.934	0.318	0.14
	Max1-Min1	0.191	2.990	-0.292	0.389	0.17
	Max3	0.215	5.180	0.970	0.262	0.09
	Max3-Min3	0.132	3.448	-0.060	0.228	0.10
9	Max1	0.206	3.144	1.159	0.304	0.16
	Max1-Min1	0.130	1.704	-0.047	0.361	0.17
	Max3	0.230	4.183	1.069	0.260	0.11
	Max3-Min3	0.081	1.760	0.052	0.278	0.10

Table 6: Comparison of Model Performance (continued)

Panel B. 1) Baseline model where the mean reversion parameter is the same for all countries, and the momentum parameter is the same for all lags and countries; 2) The mean reversion parameter is the same for all countries. The momentum parameter is the same for all lags, but is different across countries; 3) The mean reversion parameter is the same for all countries. The 12 momentum parameters are different across lags but each lag parameter is the same for all countries; 4) The mean reversion parameter is the same for all countries. The 12 momentum parameters are different across lags and countries; 5) The mean reversion parameters are different across countries, and the momentum parameter is the same for all lags and countries; 6) The mean reversion parameters are different across countries. The momentum parameter is the same for all lags, but is different across countries; 7) The mean reversion parameters are different across countries. The 12 momentum parameters are different across lags but each lag parameter is the same for all countries; and 8) The mean reversion parameters are different across countries.

Model	Portfolio	Mean Return	*t*-ratio	β with World Portfolio	Expected Return	Percentage Switches in Portfolio
1	Max1	0.180	3.401	0.962	0.318	0.13
	Max1-Min1	0.167	2.449	-0.301	0.393	0.16
	Max3	0.203	4.528	0.984	0.260	0.10
	Max3-Min3	0.119	2.964	-0.064	0.367	0.10
2	Max1	0.199	3.549	1.018	0.359	0.25
	Max1-Min1	0.157	2.228	-0.171	0.439	0.25
	Max3	0.219	5.017	0.964	0.282	0.14
	Max3-Min3	0.115	2.846	-0.090	0.320	0.15
3	Max1	0.219	4.465	0.715	0.335	0.47
	Max1-Min1	0.209	3.189	-0.326	0.433	0.53
	Max3	0.194	4.371	0.986	0.274	0.40
	Max3-Min3	0.102	2.626	-0.021	0.325	0.41
4	Max1	0.234	3.752	1.070	0.583	0.83
	Max1-Min1	0.203	2.791	0.212	0.828	0.86
	Max3	0.208	4.862	0.941	0.446	0.69
	Max3-Min3	0.143	3.952	-0.074	0.640	0.72
5	Max1	0.207	3.310	1.050	0.336	0.22
	Max1-Min1	0.178	2.283	-0.105	0.438	0.17
	Max3	0.223	4.629	1.063	0.296	0.13
	Max3-Min3	0.112	2.680	0.080	0.357	0.12
6	Max1	0.173	2.777	1.115	0.393	0.25
	Max1-Min1	0.117	1.551	-0.028	0.476	0.24
	Max3	0.203	4.081	1.106	0.325	0.15
	Max3-Min3	0.103	2.351	0.120	0.336	0.16
7	Max1	0.174	2.868	1.075	0.350	0.58
	Max1-Min1	0.110	1.425	-0.034	0.456	0.46
	Max3	0.200	4.253	1.050	0.304	0.35
	Max3-Min3	0.087	2.261	0.052	0.329	0.34
8	Max1	0.226	3.495	1.093	0.590	0.82
	Max1-Min1	0.153	1.955	0.117	0.862	0.80
	Max3	0.212	5.022	0.945	0.448	0.68
	Max3-Min3	0.135	3.717	0.010	0.589	0.69

Table 7: Performance of Portfolio Switching Strategies with Transaction Cost

The models are: 1) Momentum with mean reversion without transaction cost; 2) Momentum with mean reversion with 1% transaction cost; 3) Momentum without mean reversion with 1% transaction cost; 4) Mean reversion without momentum with 1% transaction costs; and 5) Pure random walk with 1% transaction cost.

Model	Portfolio	Mean Return	*t*-ratio	β with World Portfolio	Expected Return	Percentage Switches in Portfolio
1	Max1	0.180	3.401	0.962	0.318	0.13
	Max1-Min1	0.167	2.449	-0.301	0.393	0.16
	Max3	0.203	4.528	0.984	0.260	0.10
	Max3-Min3	0.119	2.964	-0.064	0.367	0.10
2	Max1	0.179	3.313	1.042	0.301	0.01
	Max1-Min1	0.172	2.599	-0.079	0.357	0.03
	Max3	0.184	4.104	0.988	0.248	0.02
	Max3-Min3	0.108	2.734	-0.024	0.269	0.02
3	Max1	0.127	1.757	1.334	0.185	0.05
	Max1-Min1	-0.015	-0.189	0.360	0.110	0.05
	Max3	0.125	2.671	1.094	0.158	0.03
	Max3-Min3	0.010	0.227	0.198	0.055	0.03
4	Max1	0.157	2.539	1.096	0.219	0.00
	Max1-Min1	0.088	1.543	-0.060	0.170	0.01
	Max3	0.171	4.301	0.870	0.192	0.01
	Max3-Min3	0.081	2.424	-0.241	0.134	0.01
5	Max1	0.158	2.035	1.180	0.229	0.00
	Max1-Min1	0.014	0.172	0.285	0.142	0.00
	Max3	0.117	2.132	1.143	0.198	0.00
	Max3-Min3	-0.021	-0.474	0.175	0.096	0.00

Table 8: Risk-Adjusted Excess Returns

This table reports results from regressing monthly returns of Max1 and Max3 portfolios on the excess return on the MSCI world index and the excess return on an internationally diversified portfolio of value minus growth:

$$r_{\max i,t} - r_{f,t} = \alpha + \beta_{wld}\,(r_{wld,t} - r_{f,t}) + \beta_{vmg} r_{vmg,t} + \varepsilon_t\,.$$

The U.S. T-bill rate is used as the risk-free rate. The α values are annualized.

The models considered are: 1) Baseline model where the mean reversion parameter is the same for all countries, and the momentum parameter is the same for all lags and countries; 2) Jegadeesh-Titman pure momentum; and 3) Pure mean reversion.

Model	Portfolio	Mean return	*t*-ratio	α	*t*-ratio	β_{wld}	*t*-ratio	β_{vmg}	*t*-ratio
1	Max1	0.180	3.401	0.031	0.699	0.993	11.262	0.323	1.568
	Min1	0.013	0.201	-0.156	-3.058	1.266	12.302	0.032	0.131
	Max1-Min1	0.167	2.449	0.186	2.702	-0.273	-1.959	0.291	0.896
	Max3	0.203	4.528	0.049	1.539	1.030	16.138	0.476	3.193
	Min3	0.083	1.938	-0.070	-2.545	1.063	19.011	0.162	1.244
	Max3-Min3	0.119	2.964	0.119	2.917	-0.032	-0.391	0.314	1.629
2	Max1	0.184	2.583	0.001	0.114	1.329	11.147	0.460	1.652
	Min1	0.089	1.381	-0.005	-0.944	0.936	7.874	0.258	0.931
	Max1-Min1	0.095	1.107	0.005	0.718	0.393	2.245	0.201	0.492
	Max3	0.177	3.374	0.001	0.318	1.188	15.636	0.350	1.975
	Min3	0.066	1.521	-0.006	-2.223	0.885	12.919	0.279	1.744
	Max3-Min3	0.112	2.110	0.007	1.642	0.304	2.826	0.071	0.285
3	Max1	0.198	3.983	0.069	1.519	0.683	7.403	0.697	3.234
	Min1	0.113	1.857	-0.053	-1.124	1.237	12.944	0.008	0.035
	Max1-Min1	0.085	1.248	0.122	1.858	-0.554	-4.156	0.689	2.214
	Max3	0.153	3.945	0.011	0.378	0.885	15.595	0.480	3.622
	Min3	0.120	2.758	-0.035	-1.320	1.087	20.191	0.050	0.402
	Max3-Min3	0.034	0.902	0.046	1.240	-0.203	-2.717	0.429	2.465

Fig 1(1) Mean Return of Max1 - Max 18 Portfolios
δ same, ρ same for lags and countries : Baseline

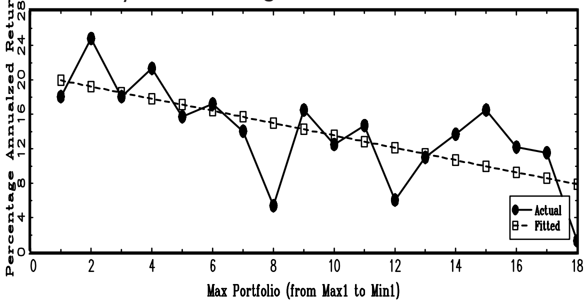

Fig 1(2) Mean Return of Max1 - Max 18 Portfolios
δ same, ρ same for lags but diff for countries

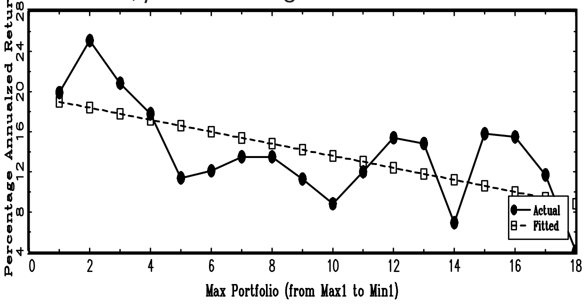

Fig 1(3) Mean Return of Max1 - Max 18 Portfolios
δ same, ρ same for countries but diff for lags

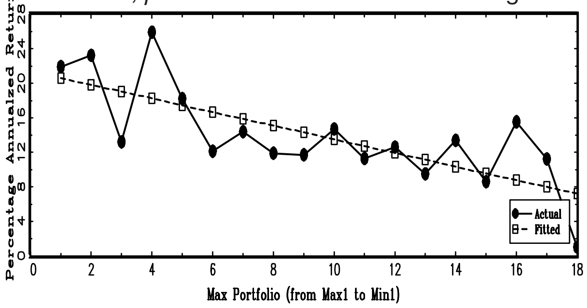

Fig 1(4) Mean Return of Max1 - Max 18 Portfolios
δ same, ρ diff for lags and countries

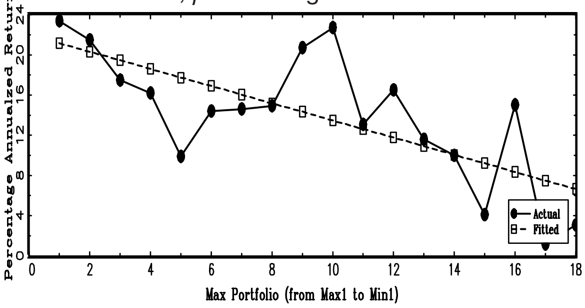

Fig 1(5) Mean Return of Max1 - Max 18 Portfolios
δ diff, ρ same for lags and countries

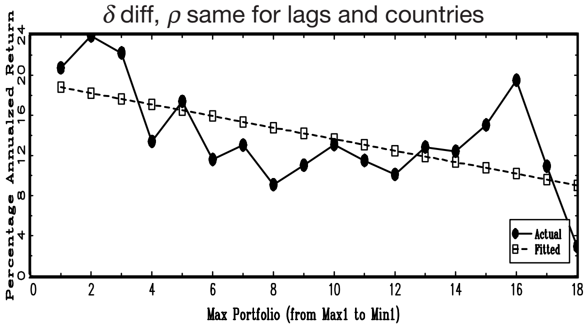

Fig 1(6) Mean Return of Max1 - Max 18 Portfolios
δ diff, ρ same for lags but diff for countries

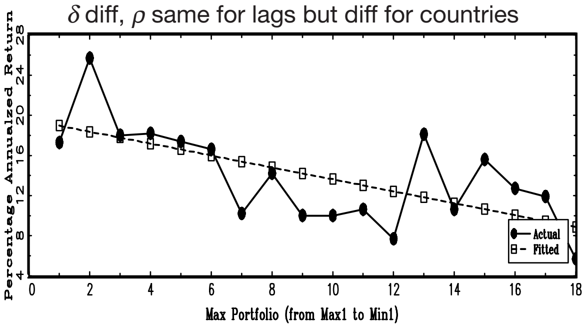

Fig 1(7) Mean Return of Max1 - Max 18 Portfolios
δ diff, ρ same for countries but diff for lags

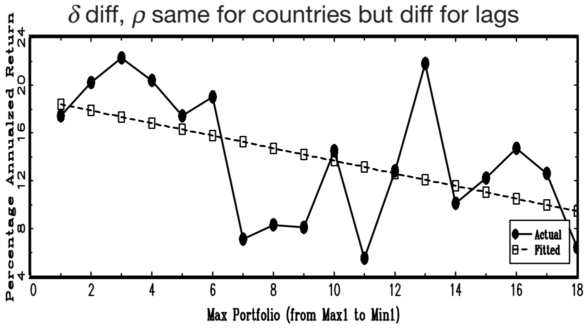

Fig 1(8) Mean Return of Max1 - Max 18 Portfolios
δ diff, ρ diff for lags and countries