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Long-run equilibrium relationships in the international stock market factor systems[*1]

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Abstract

The main objective of this paper is to investigate the international linkages among local, country-specific stock market factors in order to better understand the dependence structure of increasingly integrated world financial markets. The seeming discordance between Fama and French (1998) and Griffin (2002) regarding the multi-factor model in the international stock markets motivates us to study the international relationship among local factors. With the individual stock data from the six major developed countries in the international stock market, we compose daily returns to the Fama-French three factors (i.e. market, size, and value) and the momentum factor over the period from January 2000 to June 2010. We investigate the international linkages among local stock market factors, focusing on their equilibrium relationship in the integrated world financial market. The cointegration analysis indicates that local factor indices, constructed from the cumulative factor returns, are cointegrated for each of the four factor classes. Thus, we conclude that local factors are globally bound to each other through a long-run equilibrium relationship and that although stock market factors may be local, rather than global, individual stock returns are driven by common global stochastic trends.

Key words: *International stock markets, global market integration, multi-factor models, long-run equilibrium, cointegration*

JEL classification: *G10, G14, G15*

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1. Introduction

Perhaps reflecting the increasing integration of world financial markets, numerous studies [e.g., Eun and Shim, 1989; Hamao, Masulis, and Ng, 1990; Kasa 1992; Forbes and Rigobon, 2002] have investigated the pattern and nature of interactions among international stock markets. These studies generally find that international stock markets actively interact with each other, with the U.S. leading other markets. It is noted that with few exceptions, existing studies use broad-based stock market indices in documenting international financial linkages. However, in an integrated world financial market, not only stock market indices but also other stock return factors such as the size, value, and momentum factors known to systematically influence stock returns may be interrelated across countries. In the current paper, we purport to contribute to the literature by investigating international linkages at the factor level.

Fama and French (1998) argue that in an integrated world financial market, security returns should be generated by the same set of factors in every country. They find that a two-factor model comprising the world market factor and the world book-to-market equity factor adequately explains international stock returns. This finding is consistent with the notion of integrated world financial markets. However, Griffin (2002) documents the fact that the domestic version of the Fama-French factor model better explains the time-series behavior of stock returns and leads to lower pricing errors than the world version. Griffin thus concludes that Fama-French factors are local, that is, country-specific, rather than global. Based on his empirical finding, Griffin argues that practical applications of the Fama-French factor model, such as cost of capital estimation and investment performance evaluation, are best performed on a country-specific basis. Although Griffin's finding appears robust on empirical grounds, it raises the question of whether local factors may prevail in an integrated world financial market. This seeming discordance in the literature further motivates us to study the international relationship among local factors.

The working hypothesis is as follows: local stock market factor indices are internationally cointegrated for each of the Fama-French three factor classes and momentum class, which implies that international stock markets are integrated rather than segmented at the factor level.

The main objective of the current paper is to investigate the international linkages among local, country-specific stock market factors in order to better understand the dependence structure of increasingly integrated world financial markets. Specifically, we focus on the existence of the equilibrium relationship among local factors. In addressing these issues, we use daily returns on individual stocks to compose the Fama-French three factors (i.e., market, size, and value) and the momentum factor for each of the sample markets during the period January 2000 to June 2010. The sample comprises six major developed stock markets, i.e., Canada, Germany, Hong Kong, Japan, the United Kingdom, and the United States. It is noted that each of the three major regions of the world, i.e., North America, Asia/Pacific, and Europe, is represented by two major markets in the sample. To study the properties of the stochastic trends that drive factor returns, we introduce the notion of "factor indices," which are constructed based on the cumulative factor returns. Among other things, we conduct a cointegration analysis using the factor indices thus constructed, to test for the existence of long-run equilibrium relationship among them.

In this study, we find that each factor index follows an I(1) process, implying that each index contains a random walk component. More importantly, local factor indices are internationally cointegrated for each of the four factor classes, implying that international stock markets are integrated rather than segmented at the factor level. This means that although stock market factors may be local rather than global, as shown by Griffin (2002), local factors are globally bound to each other through a long-run equilibrium relationship. Security returns are thus affected by common global stochastic trends, consistent with Fama-French's argument. The findings here provide the first evidence on the internationally integrated nature of local stock return factors and also help reconcile the seemingly contradictory findings of Fama-French (1998) and Griffin (2002).

The structure of the paper is as follows. After the Introduction, Section 2 highlights literature on empirical findings of multi-factor asset pricing models in international stock markets. Definition of the factor index and methodology of the cointegration analysis are presented in Section 3. Section 4 describes the factor return data in our sample countries. We discuss the cointegration results in Section 5 and conclude the paper in Section 6.

2. Literature review

The current study is motivated in part by the rising popularity of multi-factor models as an alternative paradigm to the CAPM. In particular, Fama and French's (1993) three-factor model has become a popular instrument for financial analysis, applicable to a wide spectrum of corporate and investment functions such as cost of capital estimation, asset allocation, and fund performance evaluation. Due to the model's empirical success in explaining observed security returns, the Fama-French factor model is now widely regarded as a practical paradigm that can be used in lieu of the traditional CAPM.

The existence of strong size and value premium is not limited to a single market such as the United States as presented in previous studies including Chan, Hamao, and Lakonishok (1991), Capaul, Rowley, and Sharpe (1993), and Fama and French (1998). Especially, by examining returns on market, value, and growth portfolios for the United States and twelve major countries over the period from 1975 to

1995, Fama and French (1998) finds that value stocks tend to have higher returns than growth stocks in markets around the world.[3] The difference between average returns on global portfolios of high and low book-to-market stocks is 7.68 percent per year. They provide the evidence of the value premium in emerging markets as well. In addition, they argue that an international CAPM cannot explain the value premium in international returns and that the international two-factor model provides a parsimonious way to summarize the general patterns in international returns.

Griffin (2002) examines whether country-specific or global versions of Fama-French three factor model better explain time series variation in international stock returns. He specifically compares a world three-factor model to country-specific models to explain individual monthly stock returns in the United States, Canada, the United Kingdom, and Japan, which are likely to be integrated. He finds that the domestic models provide more accurate average pricing than the world models as the domestic models have lower average absolute intercepts.[4] Also, in all sample countries, the weighted domestic model average adjusted R-squares are substantially higher than the R-squares for world three-factor model regressions. He concludes that country-specific three-factor modes are more useful in explaining average stock returns than are world versions even though the stock markets are integrated internationally.

Recently, Fama and French (2012) examine stock returns in four regions (North America, Europe, Japan and Asia Pacific) to test whether asset pricing is integrated across those regions over the sample period from November 1989 to March 2011. Although stock markets are believed to be tightly integrated in these days, global models perform poorly in their tests. Instead, the tests of local models have power for portfolios formed on size and value vs. growth. The average R-square of the local four-factor model is 0.92 which is 52 % greater than the average R-square of the global factor model.

Kasa (1992) provides an interesting approach to examine the asset pricing process in the international stock markets. Kasa (1992) presents a single common stochastic trend in the developed equity markets such as the United States, Japan, the United Kingdom, Germany, and Canada using the monthly data from January 1974 through August 1990. This result indicates the presence of a single common trend driving these countries' stock markets. Following his approach, we will apply the theory of cointegration to each factor level in the international stock market to understand the relatively less power of world factors to explain the asset pricing as reported in the previous literature.

[3] Stocks can be classified as value stocks when they have high ratios of book-to-market equity, earnings to price, or cash flow to price. Otherwise, they can be classified as growth stocks.

[4] According to his analysis, regression results for the international factor models yield an average pricing error of 0.24, which is 0.02 higher than for the domestic model.

3. Methodology

In order to investigate the dynamics of international linkages among local stock return factors, it is necessary to learn how factor returns change over time in each country. In previous studies on international market linkages, such as Kasa (1992) and Arshanapalli and Doukas (1993), the authors use value-weighted market indices to determine the structure of the long-run equilibrium relationship between overall stock markets and their intertemporal dynamics. As is well known, market indices provide a perspective on the stochastic *trends* in stock return generation. In a similar vein, we construct a factor index to obtain the trend in factor return generation.

Formally, we define the factor index as the cumulative factor returns. It is sufficient to consider the factor indices for the purpose of this study since they capture the dynamic patterns of factor returns over time. If one regards factor returns as a risk premium for the factor-mimicking portfolio, the factor index can be interpreted as the cumulative factor premium from the beginning of the sample period. Mathematically, the factor index is

$$I_t(C,F) = \sum_{s=1}^{t} r_s(C,F), \text{ t = 1, 2, …, T.} \qquad (1)$$

where $r_t(C,F)$ is the daily return on a factor-mimicking portfolio, F, on day t in country C. It is noted that factor returns, and thus the factor indices, are measured in local currency units as the focus of the paper is on understanding the pattern of interactions among local stock return factors.[5]

Now we turn to discuss the inference method used to analyze the international equilibrium dynamics of each class of factor indices. All of the analyses are on the time series of the six countries' factor indices, i.e.,

$$Y_t(F) = [I_t(1,F) \ldots I_t(6,F)]' = [y_{t,1} \cdots y_{t,6}]', \qquad (2)$$

[5] The factor index described in equation (1) is an index that represents the cumulative returns from taking long and short positions. This type of return index is not completely new. For example, Deutsche Bank and PowerShare Capital Management recently introduced an exchange-traded fund that replicates a hedge fund strategy known as the "carry trade," which buys the currencies with high interest rates and sells short those with low rates. The return comes from both interest income and the expected strengthening and weakening of the exchange rates. As the fund's benchmark, the index was created to reflect the return from taking the long and short positions and exploiting the trend in the fund's performance. Also, recently, Sakamaki (2013) examines the similar cumulative factor returns to e decomposes the market volatility risks into the variance components of individual securities and the correlation components regarding upside and downside risks.

for each factor F. For simplicity, the factor notation F in $Y_t(F)$ will be omitted hereafter. We examine the presence of long-run equilibrium relations among factors in six countries by means of cointegration analysis. In general, a $p\times1$ vector Y_t is said to be cointegrated if each of its elements is I(1) and there exists at least one nonzero $p\times1$ vector β such that $\beta'Y_t$ is stationary. To check the first condition for cointegration, that is, to see if each of the elements in Y_t is an I(1) process, we apply augmented Dick-Fuller (ADF) unit root tests to each factor index, $I_t(C,F)$. We conduct the unit root test for each of the four factor indices of each country, using three different models.[6]

Once each factor index is found to be integrated of the same order, I(1), we can test for the existence of cointegrating vectors in the following representation of a multivariate system:

$$\Delta Y_t = \mu + \Pi Y_{t-1} + \sum_{j=1}^{k-1} \Gamma_j \Delta Y_{t-j} + \varepsilon_t, \tag{3}$$

where $\Delta Y_t = Y_t - Y_{t-1}$, μ is a $p\times1$ constant vector, $\Pi = \alpha\beta'$, α and β are $p\times r$ matrices of full rank r, Γ_j is a $p\times p$ matrix of coefficients, and ε_t is a $p\times1$ vector of innovations ($p = 6$ in this study) with $E(\varepsilon_t) = 0$, $E(\varepsilon_t \varepsilon'_\tau) = \Omega$ for $t = \tau$, $E(\varepsilon_t \varepsilon'_\tau) = 0$ for $t \neq \tau$. The positive rank of β suggests the presence of cointegration between elements of Y_t, in which case equation (3) becomes the vector error correction model (VECM). To determine the number of cointegrating vectors, we use the λ_{max} test and trace test statistics (Johansen 1991; Pesaran, Shin, and Smith, 2000). The choice of optimal lags (k) in equation (3) is made by the Schwarz (Bayesian) information criterion (BIC).[7] The matrix of cointegrating relations, β, provides information on how the factors are internationally related in the long-run equilibrium.

4. Empirical data and analysis

To study the pattern of international factor linkages, we focus on the six major stock markets – Canada (CA), Germany (GM), Hong Kong (HK), Japan (JP), the United Kingdom (UK), and the United States (US). It is noted that the six stock markets in the sample collectively account for 73% of the world stock market capitalization

[6] The Augmented Dickey-Fuller t-statistics for the factor index, $y_t = I_t(C,F)$, for country C and factor F. Lag lengths are determined by the BIC method. Model 1 is the basic model without drift or trend, $\Delta y_t = \beta_0 y_{t-1} + \sum_{j=1}^{k-1} \beta_j \Delta y_{t-j}$, Model 2 is with drift, $\Delta y_t = \alpha + \beta_0 y_{t-1} + \sum_{j=1}^{k-1} \beta_j \Delta y_{t-j}$, and Model 3 is with drift and trend, $\Delta y_t = \alpha_0 + \alpha_1 t + \beta_0 y_{t-1} + \sum_{j=1}^{k-1} \beta_j \Delta y_{t-j}$. The hypothesis is $H_0{:}\beta_0 = 0$, $H_A{:}\beta_0 \neq 0$.

[7] The Schwarz information criterion sets the optimal lags at two for each factor system in the cointegration analysis.

on average during the sample period.[8] To compute factor returns, we collect one-month Treasury bill or inter-bank rates, daily closing stock prices, market equity values, and market-to-book ratios in local currency units for all of the firms in each country covered by Datastream. If a country has a holiday, all the other countries' daily returns are excluded for that day as well.

We exclude American Depositary Receits (ADRs), Real Estate Investment Trusts (REITs), and units of beneficial interest from the sample because their characteristics might be different from ordinary equities. As documented by Ince and Porter (2006), Datastream also classifies as "equity" many securities that are not really common stocks. Another problem with the data set provided by Datastream relates to its practice of rounding prices to the nearest cent for U.S. securities, which can cause non-trivial differences in the calculated returns of securities with low prices. To mitigate these problems, we follow Ince and Porter's suggestion and eliminate what we consider unreasonable daily returns that are greater than 100% or less than -50% from the sample. We impose further criteria on the Canadian data. Unlike other exchanges in the sample, in Canadian exchanges, both warrants and capital pool companies (CPC) are listed as independent constituents in Datastream. CPCs are a unique corporate finance tool for emerging companies offered under the auspices of the Toronto Stock Exchange Venture Exchange (TSXV). A CPC is very similar to a venture capital fund in the U.S., but it is listed on the TSXV with a limited life time, usually 18 months. In order to expunge possible problems associated with these securities, we only select stocks with a minimum market value of two million Canadian dollars and a minimum stock price of one Canadian dollar as of the portfolio construction dates.[9]

Using 2,639 daily observations from January 3, 2000 to June 30, 2010, we calculate each of the three factors introduced by Fama and French (1993) – the market factor (MRF), size factor (SMB), and value factor (HML) – and the momentum factor (UMD) introduced by Carhart (1997).[10] It is noted that for U.S. factors, we simply use the data provided by Kenneth French's website.[11] We choose daily data for the

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[8] The market capitalization of each country comes from the *Focus Monthly Statistics* released by the World Federation of Exchanges.

[9] Griffin (2002) also employs a minimum market value condition on Canadian equities. While the minimum stock price condition may exclude very small ordinary firms, the effect is not significant because only the value-weighted returns are considered in this study. With these additional conditions, we removed 47 percent of return data for Canada and 10 percent for other countries in our sample.

[10] We download the daily closing price for individual stock in each country from Datastream to measure the daily return which is the percentage increase in the closing price of successive days. Finally, the number of firms in our sample is 6,328 for Canada; 1,621 for Germany; 1,400 for Hong Kong; 5,050 for Japan; and 6,052 for U.K.

[11] See http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

analysis in order to investigate "short-term" interactions among local factors of different countries that may not be captured with lower frequency data. The market factor (MRF) is the daily value-weighted average return on all the firms in each country covered by Datastream minus the risk-free rate. We use the one-month T-bill rate or the one-month inter-bank rate if the former is not available as a proxy for the risk-free rate.[12] Based on this criterion, the one-month T-bill rate is used for Canada, Japan, the United Kingdom, and the United States, while the one-month inter-bank rate is used for Germany and Hong Kong.

Following Fama and French (1993), we first construct factor-mimicking portfolios, and then compute factor returns. To construct the size and value factor portfolios, firms are ranked in each country independently according to their size (i.e., market equity value) and book-to-market ratio.[13] Most firms in the sample have December fiscal year-ends. Consequently, we rank stocks according to book-to-market equity values from the previous December and market capitalizations as of June 30. In Japan, the fiscal year ends in March. As a result, we rank Japanese companies according to book-to-market equity values from the previous March and market capitalizations as of September 30. Firms in the big portfolios are above the median market equity and those in the small portfolios are below the median. The book-to-market ratio breakpoints are the 30^{th} and 70^{th} percentiles, which determine the growth, neutral, and value portfolios. The size and book-to-market ratio sorting yields six portfolios for each country. The size factor (SMB) is the average return on the small portfolios minus the average return on the big portfolios, that is, SMB = 1/3 (Small Value + Small Neutral + Small Growth) – 1/3 (Big Value + Big Neutral + Big Growth). Similarly, the value factor (HML) is computed as the average return on the value portfolios minus the average return on the growth portfolios, that is, HML = 1/2 (Small Value + Big Value) – 1/2 (Small Growth + Big Growth).

In order to construct the momentum factor (UMD) portfolio for each country, six value-weighted portfolios are formed daily based on independent sorts by size and prior returns. Prior returns are measured from day -250 to day -21. The prior return breakpoints are the 30^{th} and 70^{th} percentiles, which determine the low and high prior return portfolios. The momentum factor (UMD) is the average return on the high prior return portfolios minus the average return on the low prior return portfolios, that is, UMD = 1/2 (Small High prior return + Big High prior return) – 1/2 (Small Low prior return + Big Low prior return).

[12] Following French's approach in his website, we implicitly assume that the risk-free rate is constant over a given month.

[13] We calculate the book-to-market equity ratio as the inverse of the market-to-book value ratio provided by Datastream.

Table 1: Descriptive statistics for the stock return factors

Panel A. Market Factor

Country	Mean	Standard Deviation	Skewness	Kurtosis	Serial Correlation	Durbin-Watson	Jarque-Bera
Canada	0.005%	0.816%	-0.26***	5.92***	0.002	1.996	3,887***
Germany	-0.018%	0.991%	0.40***	12.07***	0.011	1.999	16,101***
Hong Kong	-0.008%	1.194%	-0.25***	5.62***	0.039	1.998	3,497***
Japan	-0.007%	1.069%	-0.15***	2.74***	0.033	2.000	835***
U.K.	-0.013%	0.877%	-0.08*	5.21***	-0.064	1.999	2,982***
U.S.	0.004%	1.382%	-0.01	7.35***	-0.057	2.006	5,934***

Panel B. Size Factor

Country	Mean	Standard Deviation	Skewness	Kurtosis	Serial Correlation	Durbin-Watson	Jarque-Bera
Canada	0.011%	0.709%	-0.27***	5.23***	-0.059	2.001	3,063***
Germany	-0.004%	1.019%	-1.37***	18.00***	-0.010	2.004	36,433***
Hong Kong	-0.025%	1.075%	-0.70***	9.72***	0.038	2.005	10,601***
Japan	0.007%	0.782%	-0.15***	3.60***	0.001	2.000	1,434***
U.K.	0.001%	0.978%	-0.41***	4.38***	-0.019	1.999	2,181***
U.S.	0.020%	0.641%	-0.43***	4.93***	-0.040	1.996	2,750***

Panel C. Value Factor

Country	Mean	Standard Deviation	Skewness	Kurtosis	Serial Correlation	Durbin-Watson	Jarque-Bera
Canada	0.032%	0.805%	0.42***	14.06***	0.157	1.993	21,828***
Germany	0.031%	0.782%	0.47***	18.18***	0.059	1.996	36,440***
Hong Kong	0.056%	0.787%	-0.46***	5.87***	0.052	1.989	3,889***
Japan	0.051%	0.584%	-0.31***	7.07***	0.137	1.991	5,541***
U.K.	0.049%	0.609%	0.27***	3.94***	0.117	1.990	1,736***
U.S.	0.036%	0.720%	0.00	5.15***	0.055	1.990	2,913***

Panel D. Momentum Factor

Country	Mean	Standard Deviation	Skewness	Kurtosis	Serial Correlation	Durbin-Watson	Jarque-Bera
Canada	0.050%	1.027%	0.23***	14.30***	0.120	2.007	22,517***
Germany	0.059%	1.060%	-0.64***	6.42***	0.178	2.012	4,709***
Hong Kong	0.002%	1.223%	-0.47***	5.69***	0.127	2.004	3,661***
Japan	0.004%	0.932%	-0.41***	8.81***	0.203	1.998	8,602***
U.K.	0.036%	0.853%	-0.62***	9.60***	0.208	2.005	10,295***
U.S.	0.010%	1.181%	-0.78***	6.91***	0.153	2.003	5,527***

*, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Authors' calculations

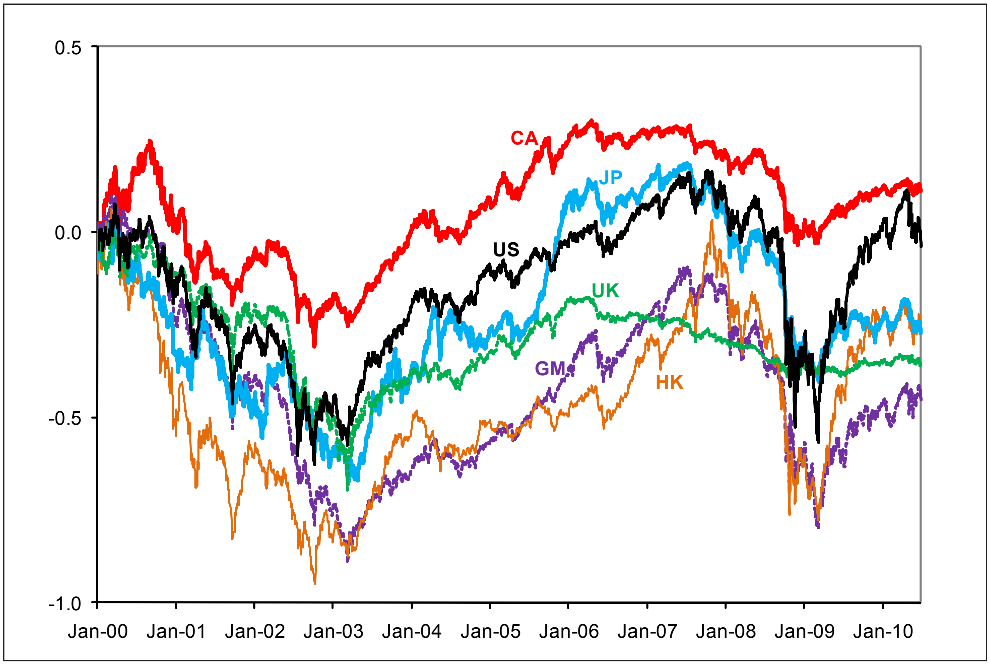
Table 1 provides descriptive summary statistics for each of the four factor classes. As can be seen from the table, the mean return to the market factor is negative for four out of six countries, probably due to the effects of turbulent events during the sample period, such as the bursting of the information technology (IT) bubble, the September 11 incident, and the global financial crisis of 2008-2009. The mean value and momentum factor returns are uniformly positive for all sample countries. The mean size factor return is mixed – negative for Germany and Hong Kong but positive for the remaining four countries. The standard deviations of daily factor returns show that the value factor return tends to be the least volatile. However, the differences in volatility seem relatively modest across factors. Table 1 also shows that daily factor returns tend to exhibit negative and significant skewness and that factor return distributions entail significant kurtosis (fat tails). Durbin-Watson tests reject the first-order serial correlation for each factor in every country. Notwithstanding, the serial correlation is noted to be substantially greater for the momentum factors than for other factors, which is consistent with the way momentum factor-mimicking portfolios are constructed. Lastly, Jarque-Bera tests reject normality for each factor in every country.[14]

Figure 1 plots the daily factor indices constructed in the manner described in the previous section. The figure shows that the four classes of factor indices of the sample countries display distinct time-series patterns. As can be seen from Panel A, all the market factor indices mostly declined until early 2003, when the information technology bubble burst, but have risen since then until late 2008 and early 2009 around the sub-prime mortgage crisis. Panel B shows that after experiencing a sharp rise and decline surrounding the bursting of the IT bubble, the size factor indices have generally drifted upward in countries such as the U.S., Canada, and Japan, while the Hong Kong market registers a significant negative size premium during the sample period. Panel C shows that the value factor indices exhibit a relatively strong upward trend in all six countries during the sample period. Panel D shows that the momentum factor indices of all countries generally increased until late 2001. Since that time, the indices stayed relatively flat in the middle of the sample period until they experienced sharp rises and declines during the recent financial crisis around late 2008 and early 2009. Based on the time series of the factor indices illustrated in Figure 1, we examine the long-run equilibrium relationship among these indices.

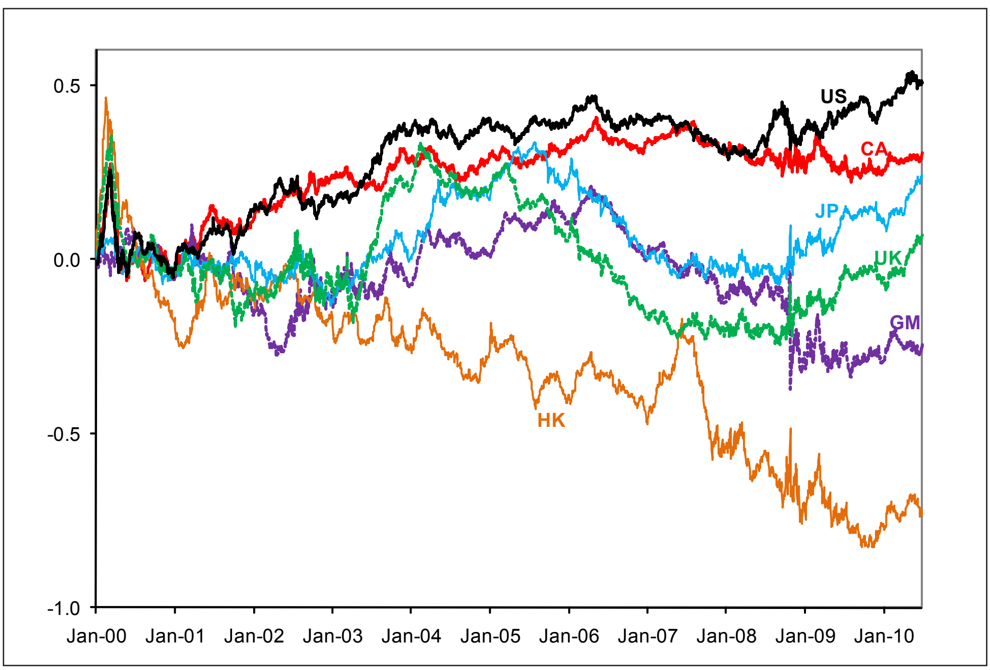
[14] This can be due to the use of daily observations. We conduct the same tests on monthly factor returns and find that monthly return distributions converge to normality. Specifically, the test results indicate that normality is rejected only in 6 out of 24 factor return series.

Figure 1: Factor index levels

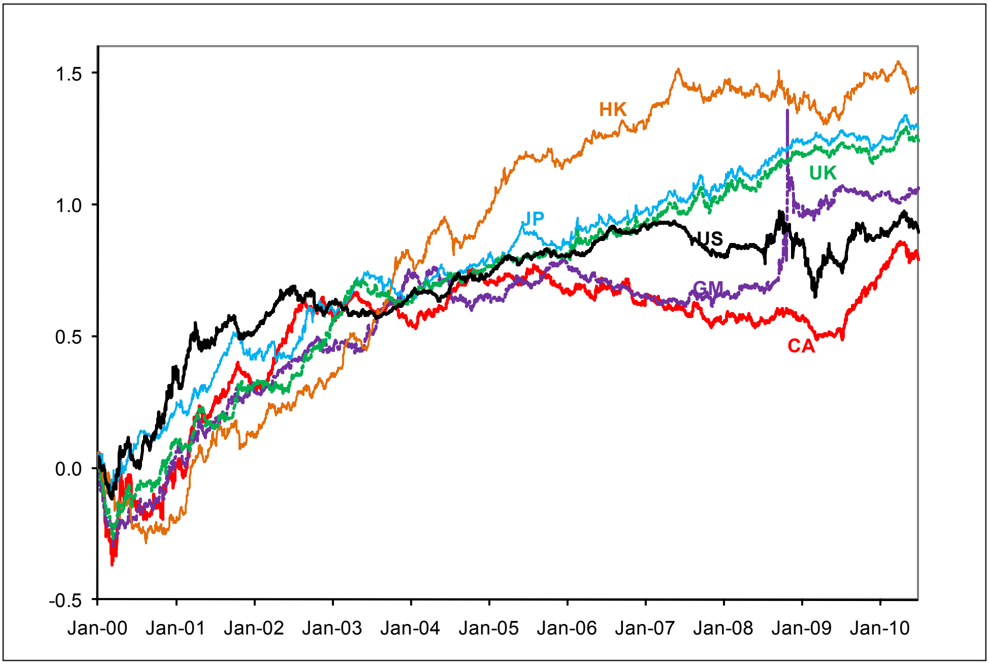
A. Market Factor Index



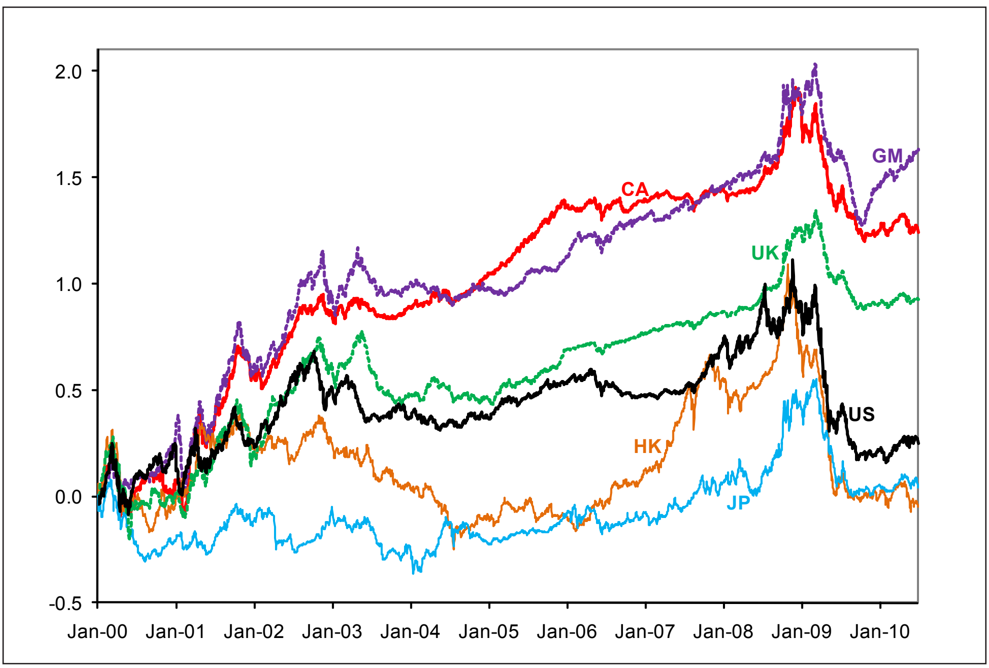
B. Size Factor Index



C. Value Factor Index



D. Momentum Factor Index



Source: Authors' calculations

For each local stock return factor index, the unit root tests are conducted and the results are represented in Table 2.

Table 2: Tests of unit roots in the factor indices

Panel A. Market Factor Index

Country	Model 1 (basic)	Model 2 (with drift only)	Model 3 (with drift and trend)
Canada	-1.211	-1.465	-1.600
Germany	-0.153	-1.962	-1.780
Hong Kong	-0.548	-2.061	-2.718
Japan	-0.705	-1.457	-1.740
U.K.	-0.057	-2.177	-2.007
U.S.	-1.377	-1.762	-2.134

Panel B. Size Factor Index

Country	Model 1 (basic)	Model 2 (with drift only)	Model 3 (with drift and trend)
Canada	-0.143	-2.329	-2.534
Germany	-1.783*	-1.887	-2.237
Hong Kong	0.394	-0.908	-3.037
Japan	-1.054	-1.545	-1.772
U.K.	-1.480	-1.476	-1.411
U.S.	0.685	-1.576	-2.289

Panel C. Value Factor Index

Country	Model 1 (basic)	Model 2 (with drift only)	Model 3 (with drift and trend)
Canada	0.701	-1.574	-1.461
Germany	1.550	-1.036	-1.432
Hong Kong	2.207	-1.227	-0.172
Japan	2.557	-1.969	-2.585
U.K.	2.437	-1.210	-1.487
U.S.	1.210	-3.157**	-2.396

Panel D. Momentum Factor Index

Country	Model 1 (basic)	Model 2 (with drift only)	Model 3 (with drift and trend)
Canada	0.877	-1.462	0.748
Germany	-2.403	-1.576	-1.616
Hong Kong	-0.684	-1.392	-1.790
Japan	1.473	-1.586	-0.655
U.K.	-1.881	-1.714	-2.266
U.S.	-0.657	-2.266	-1.717

*, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Authors' calculations

As can be seen from the table, we can reject the unit root hypothesis only in two cases, namely, the U.S. value factor index (Model 2) at the 5% level, and the German size factor index (Model 1) at the 10% level. In no case is the unit root hypothesis rejected across all model specifications for any factor. Based on the overall test results, each element in Y_t can be viewed as following an I(1) process.[15]

5. Cointegration Analysis Results and Discussion

In this section, we provide the empirical results of the cointegration analyses for each of the four six-market factor systems. Cointegration analysis allows us to test for the existence of a long-run equilibrium relationship among the corresponding local factors. If local factors are cointegrated across countries, international stock markets can be regarded as integrated at the factor level. As reported in Table 2, each factor index in the sample follows an I(1) process, implying that each index contains a random walk component. We now turn to the issue of whether the random walk components of local factor indices are independent of each other or whether they are bound to each other by a long-run equilibrium relationship. To address this issue, we conduct cointegration tests for each factor system. Specifically, for the analysis of cointegrated systems, we use the maximum likelihood approach advanced by Johansen (1991) and later generalized by Pesaran, Shin, and Smith (2000) to examine the common stochastic trends in each of the four factor systems. Statistically, this approach boils down to the determination of the rank of the long-run information matrix Π presented in equation (3).

Table 3: Tests for cointegrating relations among the factor indices

Panel A. λ_{max} Test

Hypothesis						
H_0	r = 0	r = 1	r = 2	r = 3	r = 4	r = 5
H_A	r = 1	r = 2	r = 3	r = 4	r = 5	r = 6
Test statistics						
Market Factor	59.94**	35.84**	19.65	10.10	6.16	2.91
Size Factor	46.08**	21.48	17.11	7.57	5.94	0.34
Value Factor	48.35**	41.06**	21.31	14.36	5.32	3.58
Momentum Factor	51.94**	27.48	21.89	11.16	5.84	1.75

[15] If the null hypothesis of a unit root in the factor index of a particular country is not rejected, this means that the stock market is weak-form efficient with respect to the factor. These findings suggest that each factor index behaves as a random walk in all tested countries. Thus, past factor index values cannot be used to predict the future factor index.

Panel B. Trace Test

Hypothesis						
H_0	r = 0	r = 1	r = 2	r = 3	r = 4	r = 5
H_A	r ≥ 1	r ≥ 2	r ≥ 3	r ≥ 4	r ≥ 5	r = 6
Test statistics						
Market Factor	134.58**	74.65**	38.81	19.17	9.070	2.910
Size Factor	98.53**	52.45	30.96	13.86	6.28	0.34
Value Factor	133.98**	85.63**	44.57	23.26	8.90	3.58
Momentum Factor	120.05**	68.11	40.63	18.75	7.58	1.75

*, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Authors' calculations

Table 3 provides both λ_{max} and trace statistics for the rank (r) of the matrix Π, which determines the number of cointegrating vectors. The λ_{max} statistics indicate that for each of the four factors, the null hypothesis of $r = 0$ is uniformly rejected at the 5% level. The null hypothesis of $r = 1$ is also rejected at the 5% level for the market and value factors, while it cannot be rejected for the size and momentum factors. Thus, the λ_{max} statistics suggest that the size and momentum factors have a single cointegrating vector but that the market and value factors have two cointegrating vectors. Similarly, the trace statistics indicate that for each of the four factors, the null hypothesis of $r = 0$ is rejected at the 5% level. However, the null hypothesis of $r = 1$ cannot be rejected for the size and momentum factors, while it is rejected for the market and value factors at the 5% level in favor of the alternative of $r \geq 2$.[16] Both λ_{max} and trace statistics indicate that there is a single cointegrating vector for the size and momentum factors, while there are two cointegrating vectors for the market and value factors.[17]

Overall, the cointegration tests reveal that there exists a long-run equilibrium relationship for each of the four factor classes. It is worth noting that not only the market factor indices but also each of the three non-market factor indices are all driven by common global stochastic trends of their own. The existence of a long-run equilibrium relationship among the corresponding factor indices can be viewed

[16] The tests use the critical values based on Pesaran, Shin and Smith (2000), who generalize the analysis of cointegrated systems by Johansen (1991). For a robustness check, we perform the tests using the critical values provided by Johansen (1991) and find a higher number of cointegrating vectors (not reported). Tests based on Pesaran, Shin and Smith (2000) are likely to show results that are more robust to possible model misspecification and more conservative due to the generalization.

[17] In each factor system, (CA, GM, HK, JP, UK, US), the first cointegrating vector for the market factor system is (0.283, -0.453, 0.125, 0.195, -0.585, 1.000) and the second vector is (-0.107, -0.553, -0.321, 0.020, 1.000, 0.108), the cointegrating vector for the size factor system is (0.637, 1.000, 0.172, -0.840, 0.253, -0.252), the first cointegrating vector for the value factor system is (-0.158, -0.113, 0.197, 0.266, -0.548, 1.000) and the second vector is (0.083, -0.939, -0.562, 0.370, 1.000, 0.205), and the cointegrating vector for the momentum factor system is (0.108, -0.270, 0.255, 0.412, -0.285, 1.000).

as implying that international stock markets are integrated at the factor level. Interestingly, this particular view helps us reconcile the seemingly contradictory findings of Fama and French (1998) and Griffin (2002). Fama and French (1998) argue that in integrated international capital markets, there should be a common set of risk factors that drive security returns in all countries. In particular, they find that a two-factor model comprising the world market factor and the world book-to-market equity factor adequately explains international stock returns, including the value premium prevalent in many countries, whereas the international capital asset pricing model fails to do so.

Griffin (2002), however, shows that the Fama-French factors are really local or country-specific rather than global. He shows that regressions based on the country-specific (local) factors better explain time-series variation in stock returns and generally provide more accurate pricing than those based on the common world factors. He also reports that adding foreign local factors to domestic local factors leads to less accurate pricing. In a word, Griffin documents an internationally "segmented" factor structure. Based on his finding, he maintains that practical applications of the Fama-French three-factor model, such as cost of capital calculation and fund performance evaluation, are best performed on a country-specific basis. While the Griffin's finding seems difficult to refute on empirical grounds, it is disconcerting as it appears to contradict the notion of integrated international stock markets, a conventional view in finance that is supported, directly or indirectly, by the majority of existing studies, including Harvey (1991), Kasa (1992), and De Santis and Gerard (1997) as well as Fama and French (1998). This situation begs the question of whether local factors may after all prevail in globally integrated financial markets.

The existence of cointegrating relations among local factors offers the following possible resolution to the above question. With local factors that are bound by a long-run equilibrium relationship, security returns may indeed be generated by country-specific, local factors in integrated international financial markets. Although security returns may appear to be generated by local factors, they may in fact be driven by global factors in the long run to the extent that local factors are bound to each other via an underlying equilibrium relationship. In other words, security returns can be impacted by the common global stochastic trends that drive local factors in the long run. However, since we found maximum two cointegrating vectors, there can be as many as four national factors that may follow independent non-stationary trends.

6. Conclusions

Based on the presented results, the hypothesis that local stock return factor indices are internationally cointegrated could be confirmed. The empirical findings of this study show that local Fama-French three factors and the momentum factor form a cointegrated system, with one or two cointegrating vectors at each factor level. This finding implies that international stock markets are integrated at the factor level. This further means that although stock return factors may be local as reported in the previous literature, individual stock returns are driven by common global stochastic trends. As a result, cost of capital estimation and fund performance evaluation are performed at the global level even if only domestic factors may be directly used in conducting these applications. These results imply that stock returns may be generated by local factors in an integrated world financial market.

This study does not face significant limitations except the relatively short sample period to examine the long-run equilibrium among time-series return data. If ever, the relatively short sample period would work against finding the equilibrium relationship. Thus the fact that stock return factor indices are internationally cointegrated over a relatively short sample period would strengthen the implication that individual stock returns are driven by common global stochastic trends. However, the extension of the sample period as well as including more sample countries would enable obtaining more accurate and more reliable results.

The future research in the analysis should include the relative influence of each market to others in each factor system after controlling the long-run equilibrium relation as in the vector error correction model (VECM). As the strength of the integration varies across different factor systems, we would expect the dominance of countries would be different depending upon each factor system. Moreover, future research would provide the speed of interaction in different factor systems.

The results obtained in this study suggest that local factors may be jointly driven by global comment and independent national trends. This possible reconciliation has interesting practical implications for various finance applications such as cost of capital and portfolio evaluation. Considering that the local factors are cointegrated, even if these applications may be performed on a country-specific basis, local application of the factor models does not necessarily contradict the notion of integrated international capital markets.

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Dugoročna ravnoteža odnosa sustava burzovnih čimbenika na međunarodnoj burzi[1]

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Sažetak

Glavni cilj ovog rada je istražiti međunarodne veze lokalnih čimbenika burze specifične za određenu zemlju kako bi se bolje pojmila strukturalna međuovisnost sve integriranijih svjetskih financijskih tržišta. Naizgled nesklad između Fame i Frencha (1998) i Griffina (2002) a koji se odnosi na multi-faktor model u međunarodnim burzama motivirao nas je za istraživanje međunarodnog odnosa lokalnih čimbenika. Uz podatke o individualnim dionicama šest glavnih razvijenih zemalja na međunarodnom tržištu dionica, sastavili smo dnevnu dobit u odnosu na Fama-Frenchova tri čimbenika (tj. tržište, veličina i vrijednost) i faktor stvaranja zamaha u razdoblju od siječnja 2000. do lipnja 2010. Istražujemo međunarodne veze među lokalnim čimbenicima na tržištu dionica s naglaskom na njihovu ravnotežu odnosa u integriranom svjetskom financijskom tržištu. Analiza ko-integracije pokazuje da su lokalni faktori indeksa izgrađeni od kumulativnih faktora dobiti ko-integrirani za svaki od četiri faktora klase. Dakle, možemo zaključiti da su lokalni čimbenici globalno međusobno povezani kroz dugoročni odnos ravnoteže i iako burzovni čimbenici mogu biti lokalni a ne globalni, dobit od pojedinih dionica proizlazi iz zajedničkih globalnih stohastičkih trendova.

Ključne riječi: *međunarodne burze, globalna integracija tržišta, multi-faktor modeli, dugoročna ravnoteža, ko-integracija*

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