NBER WORKING PAPER SERIES

PRICING THE GLOBAL INDUSTRY PORTFOLIOS

Stefano Cavaglia
Robert J. Hodrick
Moroz Vadim
Xiaoyan Zhang

Working Paper 9344
http://www.nber.org/papers/w9344

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
November 2002

Pricing the Global Industry Portfolios
Stefano Cavaglia, Robert J. Hodrick, Moroz Vadim, and Xiaoyan Zhang
NBER Working Paper No. 9344
November 2002
JEL No. G12, F3

ABSTRACT

We investigate the ability of several international asset pricing models to price the returns on 36 FTSE global industry portfolios. The models are the international capital asset pricing model (ICAPM), the ICAPM with exchange risks, and global two-factor and three-factor Fama-French (1996, 1998) models. We apply the methodology of Hansen and Jagannathan (1997). While all of the models can correctly price the basic assets, exchange risks are unimportant and only the global three-factor Fama-French model passes a robustness check which requires the models to also price portfolios sorted by book-to-market ratio.

Stefano Cavaglia
Brinson Partners
209 LaSalle Street
Chicago, IL 60604

Robert J. Hodrick
Columbia Business School
Uris Hall
3022 Broadway
New York, NY 10027
and NBER
rh169@columbia.edu

Moroz Vadim
Brinson Partners
209 LaSalle Street
Chicago, IL 60604

Xiaoyan Zhang
Johnson Graduate School of Management
Cornell University
Ithaca, NY 14850

1. Introduction

World financial markets are becoming more integrated. Under the market integration hypothesis, only global risks are priced, and assets with the same risk characteristics, which arise from their correlations with global risks, receive the same prices irrespective of their nationalities. Consistent with this view, Cavaglia, Brightman, and Aked (2000) demonstrate that the returns on the national industry portfolios are decided by industry-specific factors rather than by country-specific factors. This article explores whether simple international asset pricing models can price the global industry returns. Byproducts of this investigation include an exploration of investment strategies that can be implemented to beat the asset pricing benchmarks and an analysis of the gains to diversifying internationally across the global industry portfolios.

2. Industry Portfolio Returns and International Asset Pricing Models

We examine weekly excess returns on the 36 global industry indices complied by the FTSE, which cover the top 85%-95% market capitalization of 22 developed countries. Table 1 provides the names of the individual industries. The excess returns are currency hedged because they are local-currency returns in excess of the local-eurocurrency deposit rate (from Standard & Poor's DRI database). We examine the pricing of returns on portfolios that are either equal-weighted (EW) returns or value-weighted (VW). We also include the gross return on the U.S. Treasury-bill as a risk free asset that pins down the scale of excess returns. The sample period is from 1986:01 to 2001:05 for a total of 800 observations.

Figure 1 provides summary statistics for the global industry portfolios. The line with diamonds displays the mean excess weekly returns; the line without diamonds displays the two standard error band. Mean returns that exceed the standard error band are significantly different from zero. Although big spreads exist between the average returns of different industry portfolios, especially for EW returns, the noisiness of returns inflates the standard errors and makes statistical inference difficult, which lowers the power of our tests. Industry 20, business services/computer software, has the highest and the most significant mean return, and industry 34, precious metal/minerals, has the lowest mean return.

If world equity markets are integrated, differences in the average returns should be attributable to differences in the assets' exposures to global risk factors specified in international asset pricing models. One benchmark model is the International Capital Asset Pricing Model (ICAPM) as in Grauer, Litzenberger and Stehle (1976), who assume Purchasing Power Parity (PPP) holds and demonstrate that the covariance of a return with the global market return is the only priced risk. We use the global value-weighted market excess return (WRVW) as the global market risk factor.

When PPP does not hold, covariances with exchange rates become potential sources of risk in international asset pricing models as first noted in Adler and Dumas (1983). Our second model (ICAPMEX) includes exchange risks, as in Dumas and Solnik (1995). We use exchange-rate data from the DRI database, and we consider exposures to the Dollar/Pound (EXUK), Dollar/Mark (EXGE), and Dollar/Yen (EXJP) exchange rates. We calculate the exchange risks as the excess dollar returns on foreign currency deposits.

Finally, Fama and French (1998) document that exposures only to market risk (as in the ICAPM) do not explain average returns across countries, especially on country portfolios sorted by the ratio of a firm's book value to its market value. Fama and French (1998) add a second factor, the global excess return of high book-to-market firms over low book-to-market firms (WHML), and they demonstrate that this multifactor international model explains the data. Our first multifactor model (denoted IFF2) follows the lead of Fama and French and includes WRVW and WHML. In pricing the US domestic equity market, Fama and French (1996) include the excess return of small firms over big firms as an additional factor. Consistent with this approach, we also construct a third factor, the global excess return of small firms over big firms (WSMB). This multifactor model is denoted IFF3. Because WHML and WSMB are empirically motivated, we construct them in two ways using either data sorted by industry or simply individual firm data. The models are referred to as IFF2(a), IFF3(a), IFF2(b) and IFF3(b), respectively. We only use EW factors to price the EW returns, and we only use VW factors to price VW returns.

3. Methodology: Hansen-Jagannathan Distance

We use the methodology of Hansen and Jagannathan (1997) to evaluate the ability of the various international models to price the global industry portfolios. Denote the base asset returns by R and let their prices be given by p. If an element of R is an excess return, the respective element of p is zero; whereas if the element of R is a gross return, the respective element of p is one. In the absence of arbitrage it is well known that there exists a set of true discount factors, m, which correctly price the returns. That is,

$$E(mR) = p\,. \tag{1}$$

Because the true discount factors are not observable, we must use an asset pricing model that provides a proxy discount factor, y. Hansen and Jagannathan (1997) develop a methodology to measure the minimum distance from the proxy y to the true discount factor m. We refer to this measurement as HJ-distance, and it is given by usual second moment distance metric between two random variables:

$$d = \min\|y - m\|\,. \tag{2}$$

The solution for d is

$$d = \left\{ E(yR - p)[E(RR')]^{-1} E(yR - p) \right\}^{1/2} . \qquad (3)$$

This expression is the square root of a quadratic form. The vector contains the pricing errors, which are the differences between the prices given by y and the actual prices, p, given by m. The weighting matrix for the pricing errors is the inverse of the second moment of R. If the model is correctly specified, y is a true discount factor, and the pricing errors should all be zero, in which case d is also zero. But, if the model is wrong and the pricing errors are non-zero, d will be positive. The magnitude of d tells us the degree of mispricing, and it can be directly compared across models. Moreover, the distribution of d under the null hypothesis of correct asset pricing is known, which allows us to examine whether d is significantly different from zero.

The international pricing models are linear factor models, in which case the proxy discount factor, y, can be written as

$$y = b'F , \qquad (4)$$

where F denotes the risk factors and b denotes the prices of the risk factors. We estimate b to minimize the HJ-distance, which is a standard generalized method of moments (Hansen's (1982) GMM) problem. But, the weighting matrix differs from that in optimal GMM, which provides the smallest standard errors for the parameters and the most stringent specification test of the model. For optimal GMM, the weighting matrix is model dependent. In summary, the uniform weighting matrix of the HJ-distance provides a fair comparison across models, but we also use optimal GMM to check the robustness of the HJ-distance methodology.

Hansen and Jagannathan (1997) demonstrate that *d* also represents the maximum normalized pricing error of the given model for a portfolio formed from the base assets. The portfolio weights for this maximum-error portfolio are

$$w = \frac{1}{d}\left[E(RR')\right]^{-1} E(yR - p)\,, \tag{5}$$

in which case *E(yR-p)'w* = *d* is the portfolio's pricing error and ||*w'R*|| =1 is the portfolio's second moment. We refer to this maximum-error portfolio as the arbitrage portfolio, because *w* tells us how to take the biggest advantage of the model's mispricing. If a portfolio manager is being evaluated solely relative to the international asset pricing model, the arbitrage portfolio is the portfolio he should hold to best outperform the benchmark model. We report standardized weights by scaling *w* to make the standardized weights sum to one.

In general, the HJ-distance methodology has some potential weaknesses, such as small sample biases and possible parameter instability. In our case with 800 observations, small sample bias is not a severe problem. We also conduct stability tests and find that the parameters of the models appear to be stable.

4. Empirical Results

Table 2 presents empirical results for both EW returns and VW returns. We first report the magnitudes of the HJ-distances. Since *d* is a new distance measure, which is unintuitive to some, we also provide the maximum annual pricing error, Max. Err., for a portfolio with an annual standard error of 20%. On average, the annual pricing errors for all models are between 3% and 4% per year. The p-values of the tests that HJ-distance is zero, p(d=0), are all quite large, which is consistent with the moderate pricing errors. Thus, the HJ-distance tests are unable to reject any of the international asset pricing models. This implies that the international asset pricing models are able to price the return spreads of the global industry portfolios. The p-values from the J-tests of optimal GMM, p(J), provide similar implications. Notice also that the p-values for the EW returns are somewhat smaller than those of the VW returns, indicating that the EW returns are somewhat harder to price than the VW returns. This is due to the fact that the EW industry returns are more significant, as we reported in Figure 1.

By directly comparing the HJ-distance measure across the models, we find that including exchange risks does not improve significantly on ICAPM, but including the Fama-French factors does offer more improvement. In fact, the IFF3 models obtain the smallest HJ-distance for both EW and VW industry returns. The performances of IFF3(a) and IFF3(b) are very similar. Next, we clarify how the individual factors are priced in each model.

5. Factor Analysis and Factor Risk Prices

As a preliminary step in our analysis, we first conduct factor analysis to explore the covariance structure of the global industry portfolios because an individual portfolio is priced due to its correlation with common global risk factors. Table 3 displays the results from principle component factorization. For the EW returns, the first four principle components explain about 80% of the total variance. For the VW returns, the first four principle components explain 70% of the total variance.

Table 3 also reports the correlation of the pricing factors to help identify what the principle components are. For both EW and VW returns, the dominant principle components have the highest correlations with the world market risk factor.

None of the exchange risk factors have high correlations with the four principle components. This implies that the exchange risk factors cannot explain much of the covariance structure of the global industry portfolios. These results are consistent with

Griffin and Stulz (2001) who investigate whether shocks to exchange rates explain industry returns in six major countries. They find that generally less than one percent of the weekly variance of industry returns in a country is explained by the change in the exchange rate of that country's currency versus the dollar.

Both WSMB(a & b) and WHML(a & b) have higher correlations with the variance factors than do exchange risk factors. Thus, from the perspective of explaining the covariance between global industry portfolios, IFF3 should outperform the ICAPMEX.

Until this point, when we talk about risk prices, we mean the factor risk prices *b* as in equation (4). Equation (1) has an equivalent but more popular representation,

$$E(R) = \sum_{i=1}^{k} \beta_i \Lambda_i \,, \qquad (6)$$

where *k* is the number of factors, the β_i represent the vectors of sensitivities of the returns to the *i*-th risk, and the prices of the beta risks are Λ_i, $i = 1, \ldots, k$. Both β_i and Λ_i are functions of *b*. The significance of the Λ_i indicates whether the *i*-th risk is important for expected returns on the underlying assets. Table 4 reports the estimates of the beta risk prices with their standard errors in parenthesis derived from the HJ-distance methodology. Notice that the world market risk is always significantly priced, especially for EW returns. None of the exchange risks are significantly priced, while either the WHML or the WSMB factor is significantly priced for EW and VW returns. Consistent with the declining importance of the small firm effect, the world price of WSMB is consistently negative.

6. Pricing Errors and Arbitrage Portfolio

Pricing errors are the differences between the asset prices given by the proxy discount factor, *y*, and the real price, *p*. A more popular pricing error, Jensen's α, is simply the product of our pricing error measure and the riskfree rate. We can examine the individual pricing errors to see the model's ability to price the cross-sectional returns. To save space, Figure 2 only presents the pricing errors for the successful model, IFF3(b). The lines with diamonds are the pricing errors, and the other two lines are the two standard error bands. Most pricing errors are smaller than 0.05% per week, and none of them are significant, for both EW and VW returns. Given that the riskfree rate is very close to one, Jensen's α should also be smaller than 0.05% per week and insignificantly different from zero. Overall, IFF3(b) captures the cross-sectional average return spreads for the global industry portfolios.

Since HJ-distance is the maximum error for the normalized portfolio, we can take the biggest advantage of the pricing errors by investing the arbitrage portfolio specified in equation (5). Figure 3 reports the standardized weights for the arbitrage portfolio for both EW and VW returns. It is interesting to find that the portfolios put big weights on the industries with large pricing errors. For instance, there is a big weight on the VW industry 20 (business service/computer software), which is the most under-priced of the VW portfolios. Since there are big spreads among the pricing errors for VW returns, the weights on VW returns are more drastic than for EW returns. However, even for the EW returns, the arbitrage portfolio weights require the investor to have very long and very short positions on individual industries with magnitudes between –300% to 300% of invested wealth, which is not realistic. Thus, it is quite hard to beat the IFF3(b) benchmark.

7. Robustness

To check whether the estimated models are robust, we use the parameters estimated from the returns on the global industry portfolios to price returns on the global industry portfolios sorted by size (market capitalization) and book-to-market ratio. We refer to firms with high B/M ratios as value firms, and firms with low B/M ratios as growth firms. Thus, we have four new sets of assets that we label the small, big, value, and growth portfolios. Examination of the mean returns and standard errors for these portfolios indicates that the excess returns on small firms, big firms and growth firms are insignificantly different from zero, except for the big or growth firms in industry 20 (business service/computer software). However, for value firms, several returns are very significant, as in Figure 4. Fama and French (1998) and Arshanapalli, Coggin, and Doukas (1998) also find that value firms have high average returns across countries.

If the models with the original parameters are robust and the new assets share the same risk characteristics as the original assets, the original models should be able to price the new assets. Table 5 provides the p-values for the HJ-distance tests using the original parameters but pricing the new assets. As expected, since the small, big and growth industry portfolios do not have particularly significant returns, the original models are able to price them. But, all the models encounter more difficulty when they are required to price the value industry portfolios. For the VW portfolios, the p-values for the first four models (ranging from .14 to .18) indicate that the models only marginally pass the HJ-distance tests. For the EW portfolios, the ICAPM, ICAPMEX and IFF2(a) models have p-values no bigger than .05 indicating that they are not the true model. The two IFF3 models do somewhat better although their p-values are only .12 and .15. This implies that the benchmark models estimated from global industry portfolios have some difficulty pricing the value industry portfolios.

To take the advantage of this mispricing, we also report the weights on the arbitrage portfolio for the value industry portfolios for IFF3(b) in Figure 5. The weights from both EW and VW returns convey the same information, because they put big weights on the same portfolios, which are the hardest to price correctly. We need to have big short positions on industry 4 (insurance) and industry 10 (transportation) because they are over-priced by the benchmark model IFF3(b). We also need to have big long positions on industry 9 (utility) and industry 16 (health/personal care) because they are most under-priced.

8. Short-selling Constraints

Above, we found that to take the advantage of model's mispricing of the industry portfolios requires investors to have large long and short positions on particular individual portfolios. Since many fund managers face short-selling constraints for cross-border investments, the above investment strategy may be difficult to implement. In this section, we investigate how much the short-selling constraints affect the investor's investment strategy on industry portfolios to beat the benchmark model and how they should optimally allocate their wealth accordingly. Since it is difficult to impose the short-selling constraints within the pricing kernel framework analytically, here we apply the classic mean-variance frontier analysis by Monte Carlo simulations, as in Li, Sarkar, and Wang (2002).

Every asset pricing model implies an efficient benchmark investment frontier that characterizes the returns' mean-variance tradeoff. For instance, the benchmark frontier implied by ICAPM is the linear combination of the world market portfolio and the riskfree rate, and the benchmark frontier implied by IFF3 is the linear combination of the riskfree rate and the optimal factor portfolio, which is a convex combination of the Fama-French factor portfolios that achieves the highest Sharpe ratio. When we include more assets (e.g. industry portfolios) in addition to the benchmark frontier, we potentially improve the investment opportunities. If the benchmark model cannot completely capture the risks in the new assets, we may significantly improve the mean-variance tradeoff and obtain an improved frontier. However, the magnitude and significance of the improvement will be affected by the short-selling constraints, because the new optimal portfolio weights might be unavailable.

We focus on the improvement in Sharpe ratios to measure the impact of the short-selling constraints. Since HJ-distance can be interpreted as the maximum difference in the Sharpe ratios obtained by the benchmark model and the underlying assets (industry portfolios), this allows us to make a comparison between the two approaches.

Since the mean-variance frontier is completely determined by the first two moments of the base assets, we assume $\begin{pmatrix} R \\ R_B \end{pmatrix} \sim N(\mu, \Omega)$, where R is a vector of industry portfolio returns and R_B is the return on the tangency portfolio (with the highest Sharpe ratio) for the benchmark frontier. Denote the maximum improvement on the benchmark Sharpe ratio as

$$\pi = \max_{w}\left(\frac{w'\mu - r_f}{w'\Omega w} - \frac{w_B'\mu - r_f}{w_B'\Omega w_B}\right), \qquad (7)$$

where w and w_B are the portfolio weights, $w'\iota = w_B'\iota = 1$, and ι is a vector of ones. The weights w_B allocate weight 1 to R_B and 0 to the other assets. If there is improvement in the mean-variance tradeoff when we include the industry portfolios, π should be positive and significant. We can easily impose the short-selling constraints by requiring that every element of w to be non-negative. Denote the counterpart of π under these constraints as π^S. Following Li, Sarkar, and Wang (2002), we conduct 10,000 simulations to specify the empirical distributions of the diversification benefit measures: π and π^S.

Table 6 provides summary statistics for π and π^S when we use the value-weighted industry portfolios to improve the efficient frontier implied by IFF3(b). Using IFF3(a) or the equal-weighted portfolios gives similar results. When there are no short-selling constraints, the Sharpe ratio improvement (π) is about 0.185, and it is significantly different form zero. The magnitude of π is comparable with the HJ-distance measure for value-weighted industry portfolios presented in Table 2. But, in Table 2, the models are able to pass the specification test, which implies the difference in Sharpe ratios is not significant. This is consistent with our claim that due to the high volatility inherent in weekly returns, HJ-distance test has low power. The second part of Table 6 presents the portfolio weights to achieve this big improvement over Sharpe ratio. The investors put 90% of their portfolio investment in the benchmark tangency portfolio, which implies that IFF3(b) can capture most of the risks in the industry portfolios. We have big short positions on industry 4(insurance), industry 18 (entertainment), and industry 24 (computer). The magnitude of the short positions is 30-50% of the investment. Hence, if there are short-selling constraints, this improvement in the Sharpe ratio might be unachievable. We have big long positions on industry 7(oil/gas), industry 16(health/personal care), and industry 20 (business service). All the big positions are consistent with the weights of the arbitrage portfolios using HJ-distance in Figure 3.

As expected, when the short-selling constraints are imposed, the Sharpe ratio improvement (π^S) is only about 0.0324. This implies that it is hard to beat the benchmark portfolio under the short-selling constraints. We still have big long positions on industry 7(oil/gas), industry 16(health/personal care), and industry 20 (business service).

9. Conclusions

This article explores the ability of several international asset-pricing models to explain the average returns on a set of global industry portfolios. The general noisiness of the data makes it difficult to accurately estimate average returns. Thus, all of the international models are able to capture the cross-sectional industry return spreads. The world market risk is always priced, but the exchange risks are generally not. Our international Fama-French three-factor model has the smallest pricing errors, and it is the only one that can marginally pass a robustness test in which the international asset-pricing models are required to price the high B/M ratio industry portfolios.

We therefore conclude that global industry returns are consistent with a globally integrated equity market. This conclusion contrasts with the finding of Griffin (2001) who examines whether a global version or country-specific versions of the Fama-French model better explain country returns. Griffin finds that to explain country returns, the local Fama-French factors do a better job than the global Fama-French factors. More analysis of this issue would be useful.

Zhang (2001) also tests alternative international asset pricing models using size and book-to-market portfolios from several developed countries. She finds that time-variation in risk prices are important determinants of cross-sectional return spreads. Our unconditional asset pricing tests do not allow explicitly for the prices of risks to vary over time. A potential reconciliation of the results in the two papers may be that the global Fama-French factors proxy for time-variation in prices of other fundamental risks. This is also a promising area for additional research.

Finally, our methodology results in an investment strategy that maximally exploits the potential mispricings of the benchmark models. When there are no short-selling constraints, investing in the industry portfolios provides a big diversification benefit relative to investing in the benchmark assets, but the benefit becomes marginal when there are short-selling constraints.

References

Adler, M. Dumas, B., 1983. International portfolio selection and corporation finance: a synthesis. Journal of Finance 38, 925-984.

Arshanapalli, B. T., Coggin, D., Doukas, J., 1998. Multifactor asset pricing analysis of international value investment strategies. Journal of Portfolio Management 24, 10-23.

Cavaglia, S., Brightman, C., Aked, M, 2000. The increasing importance of industry factors. Financial Analysts Journal 56, 41-54.

Dumas, B., Solnik, B., 1995. The world price of foreign exchange risk. Journal of Finance 50, 445-479.

Fama. E. F., French, K. R., 1996, Multifactor explanations of asset pricing anomalies. Journal of Finance 47, 427-465.

Fama, E. F., French, K. R., 1998. Value versus growth: the international evidence. Journal of Finance 53, 1975-1999.

Grauer, F. L. A., Litzenberger, R. H., Stehle, R. E., 1976. Sharing rules and equilibrium in an international capital market under uncertainty. Journal of Financial Economics 3, 233-256.

Griffin, J., 2001. Are the Fama and French factors global or country-specific? forthcoming in Review of Financial Studies.

Griffin, J., Stulz, R. M., 2001. International competition and exchange rate shocks: A cross-country industry analysis. Review of Financial Studies 14, 215-241.

Hansen, L. P., 1982. Large sample properties of generalized method of moments estimators. Econometrica 50, 1029-1054.

Hansen, L. P., Jagannathan, R., 1997, Assessing specification errors in stochastic discount factor models. Journal of Finance 52, 557-590.

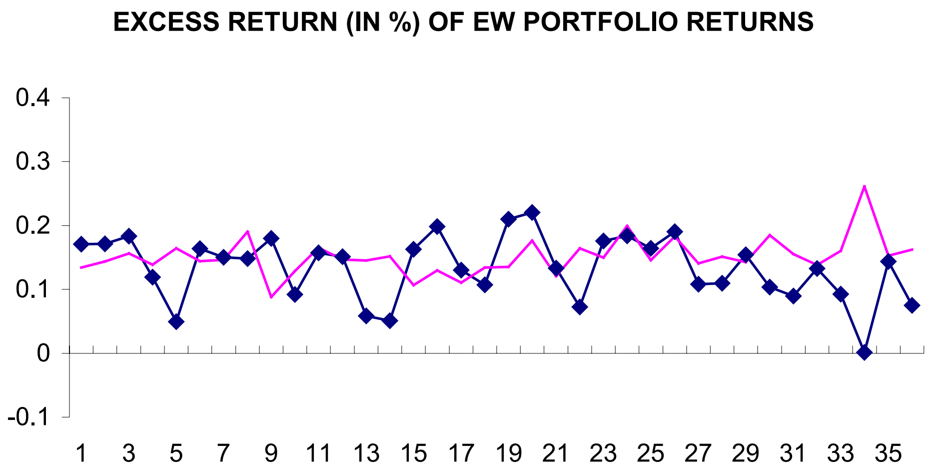
Li, K., Sarkar, A., Wang, Z., 2002. Diversification benefits of emerging markets subject to portfolio constraints. Forthcoming Journal of Empirical Finance.

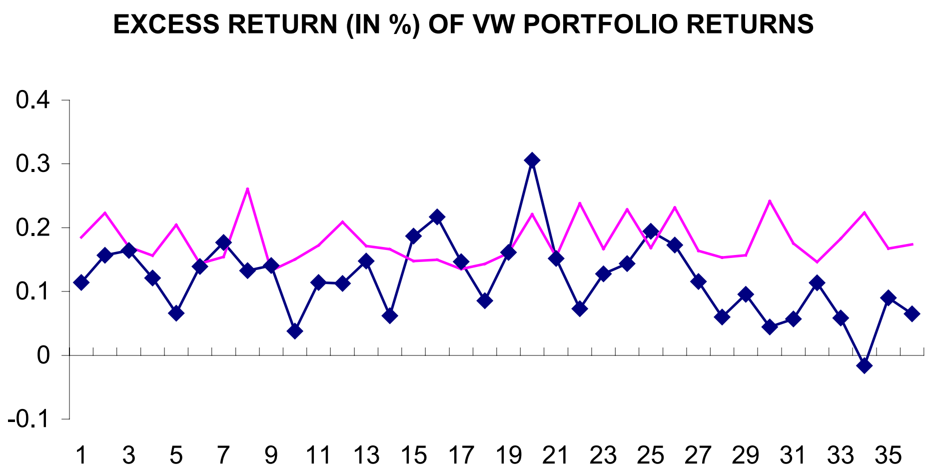
Zhang, X., 2001. Specification test of international asset pricing models. Manuscript, Johnson Graduate School of Business, Cornell University.

Table 1. Industry Classifications for FTSE Indices

1	BANKS	13	DIVERS CONSUMER GDS/SVC	25	ELECTRICAL EQUIPMENT
2	FINANCIAL INST/SERV	14	TEXTILE/CLOTHING	26	ELECTRONICS/INSTRUMT
3	INSURANCE-LIFE/AGTS/BRKRS	15	BEVERAGES/TOBACCO	27	MACHINERY/ENGINEERING SVC
4	INSURANCE-MULTI/PROP/CAS	16	HEALTH/PERSONAL CARE	28	AUTO COMPONENTS
5	REAL ESTATE	17	FOOD/GROCERY PRODUCTS	29	DIVERS INDUST MANF
6	DIVERSIFIED HOLDING COS	18	ENTERTAINMENT/LEISURE/TOYS	30	HEAVY ENG/SHIPBUILD
7	OIL/GAS	19	MEDIA	31	CONSTRUCT/BUILDG MAT
8	OTHER ENERGY	20	BUSINESS SVC/COMP SOFTWARE	32	CHEMICALS
9	UTILITIES	21	RETAIL TRADE	33	MINING/METAL/MINERALS
10	TRANSPORT/STORAGE	22	WHOLESALE TRADE	34	PRECIOUS METAL/MINERALS
11	AUTOMOBILES	23	AEROSPACE/DEFENCE	35	FORESTRY/PAPER PRODUCTS
12	HSEHLD DURABLES/APPLIANCES	24	COMPS/COMMS/OFFICE EQUIP	36	FABR METAL PRODUCTS

Figure 1. Mean returns and standard errors for the weekly excess returns





The basic returns are local excess returns of the 36 FTSE industries. Weekly data are from 1986:01 to 2001:05. The line with the diamonds is the mean returns, and the line without diamonds provides the two standard error band. All numbers are in % per week.

Table 2. Summary Statistics of HJ-distance

MODEL	ICAPM	ICAPMEX	IFF2(a)	IFF2(b)	IFF3(a)	IFF3(b)
EW returns						
HJ-dist (d)	0.219	0.214	0.216	0.204	0.188	0.186
Max. Err	4.39%	4.29%	4.33%	4.09%	3.77%	3.73%
p (d=0)	0.350	0.330	0.342	0.607	0.779	0.811
p (J)	0.374	0.444	0.346	0.597	0.759	0.783
VW returns						
HJ-dist (d)	0.168	0.159	0.163	0.167	0.148	0.143
Max. Err	3.37%	3.19%	3.27%	3.35%	2.97%	2.87%
p (d=0)	0.948	0.961	0.959	0.943	0.988	0.994
p (J)	0.952	0.960	0.954	0.953	0.989	0.995

The basic returns are local excess returns of the 36 FT industries and the return on the US T-bill. Weekly data are from 1986:01 to 2001:05. The models are an international CAPM (ICAPM), an international CAPM with exchange risks (ICAPMEX), and two-factor or three factor Fama-French models. IFF2(a) and IFF3(a) use WHML and WSMB constructed from national industry indices; IFF2(b) and IFF3(b) use WHML and WSMB constructed from individual firms. HJ-dist (d) is Hansen-Jagannathan distance. The p-value for the test d =0 calculated under the null d =0 is p (d =0). Max. Error is the maximum annual pricing error for a portfolio with annual standard deviation of 20% under the assumption E(m) = E(y). The p-value of the optimal GMM test is p (J).

Table 3. Factor Analysis

	% variance explained	Correlations							
		WMKT	EXGE	EXJP	EXUK	WSMB(a)	WHML(a)	WSMB(b)	WHML(b)
EW returns									
FAC 1	0.61	0.89	-0.12	-0.02	-0.10	-0.18	-0.19	0.13	0.00
FAC 2	0.08	-0.13	0.15	0.16	0.10	0.18	0.06	-0.10	0.09
FAC 3	0.06	0.17	-0.06	-0.09	-0.05	-0.22	0.01	0.03	-0.22
FAC 4	0.04	-0.03	0.08	0.05	0.06	0.05	-0.53	-0.12	0.50
VW returns									
FAC 1	0.50	0.97	-0.11	-0.02	-0.07	-0.30	-0.25	0.26	-0.02
FAC 2	0.08	-0.09	0.12	0.16	0.09	0.22	0.08	-0.08	0.19
FAC 3	0.07	-0.02	-0.05	-0.09	-0.06	0.15	0.59	-0.16	-0.45
FAC 4	0.05	-0.09	0.06	0.05	0.05	0.18	-0.13	-0.25	0.33

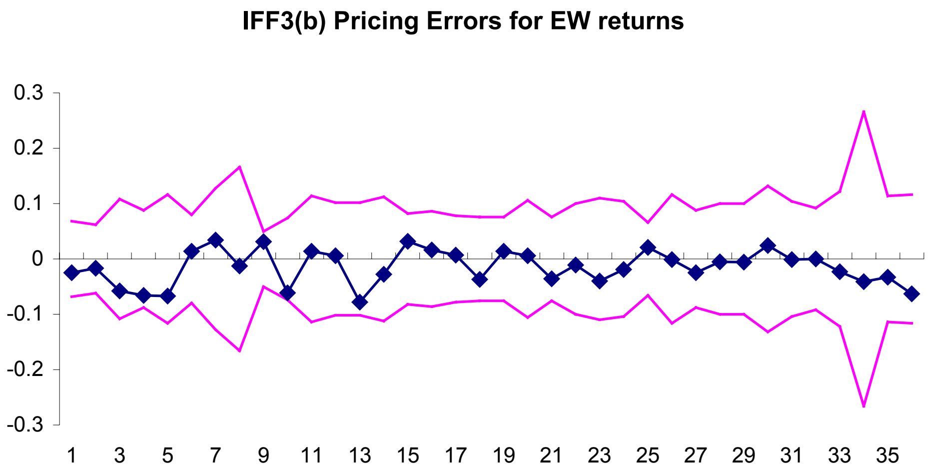
The basic returns are local excess returns of the 36 FT industries and the return on the US T-bill. Factor analysis is conducted by principle component factorization on the covariance matrix. WMKT is the excess return on the world market portfolio. EXGE, EXJP, and EXUK are dollar excess returns on currency investments. WSMB(a) and WHML(a) are constructed from the national industry indices; WSMB(b) and WHML(b) are constructed from individual firms.

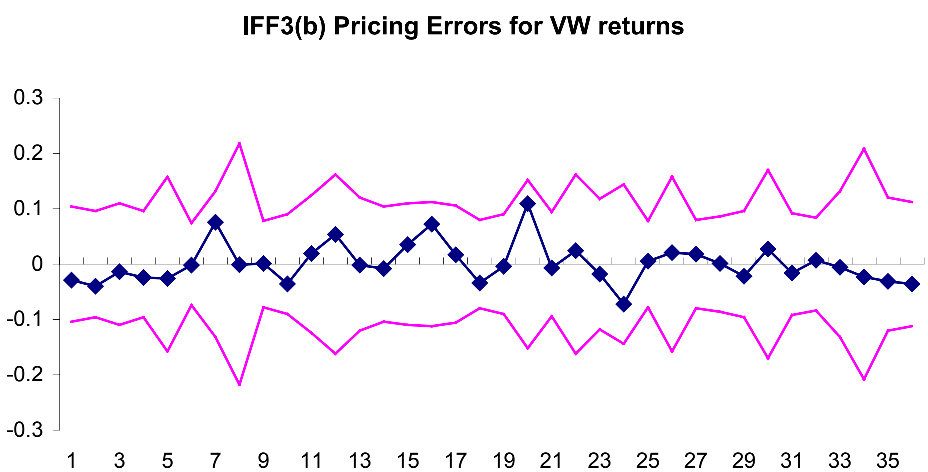
Table 4. Risk Prices

FACTORS	WRVW	EXGE	EXJP	EXUK	WSMB(a)	WHML(a)	WSMB(b)	WHML(b)
EW returns								
ICAPM	0.22							
	(0.08)							
ICAPMEX	0.22	-0.16	-0.14	0.14				
	(0.08)	(0.21)	(0.21)	(0.28)				
IFF2(a)	0.22					0.08		
	(0.08)					(0.08)		
IFF2(b)	0.28							0.34
	(0.09)							(0.12)
IFF3(a)	0.24				-0.27	0.14		
	(0.08)				(0.10)	(0.09)		
IFF3(b)	0.27						-0.38	0.09
	(0.10)						(0.11)	(0.12)
VW returns								
ICAPM	0.15							
	(0.07)							
ICAPMEX	0.15	-0.29	0.10	0.10				
	(0.07)	(0.20)	(0.18)	(0.29)				
IFF2(a)	0.15					0.09		
	(0.07)					(0.08)		
IFF2(b)	0.15							0.17
	(0.08)							(0.11)
IFF3(a)	0.15				-0.13	0.17		
	(0.07)				(0.09)	(0.09)		
IFF3(b)	0.13						-0.30	0.04
	(0.08)						(0.11)	(0.10)

The basic returns are local excess returns of the 36 FT industries and the return on the US T-bill. The models are an international CAPM (ICAPM), an international CAPM with exchange risks (ICAPMEX), and two-factor or three factor Fama-French models. WHML(a) and WSMB(a) are constructed from national industry indices; WHML(b) and WSMB(b) are constructed from individual firms. The estimated parameters, $\hat{\lambda}$, are the beta risk prices as in equation (6). The standard errors for the parameter estimates are provided in the parentheses.

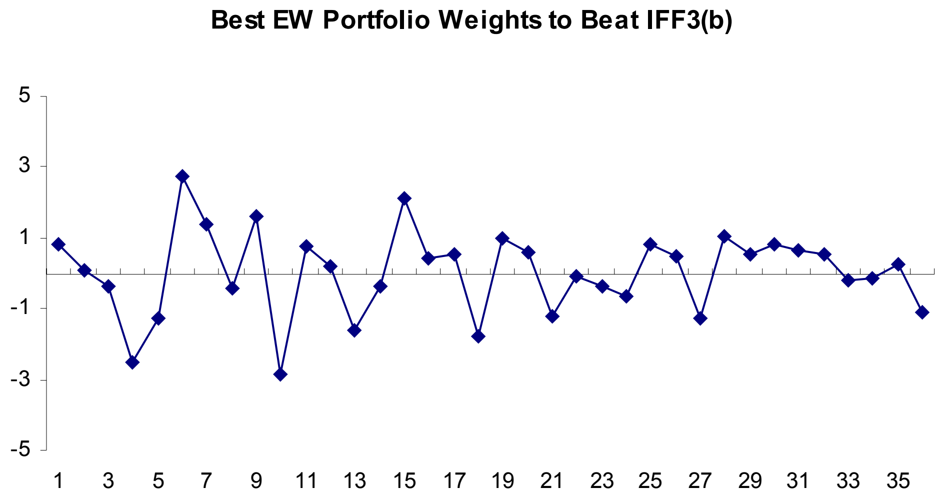
Figure 2. Pricing errors for IFF3(b)

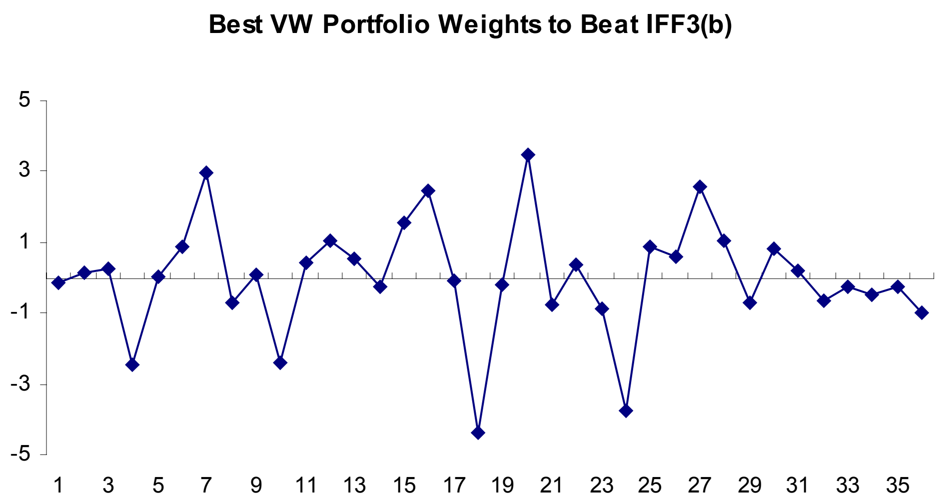




The basic returns are local excess returns of the 36 FT industries. Weekly data are from 1986:01 to 2001:05. The line with the diamonds is the pricing errors, and the line without is the two standard error band. All numbers are in % per week. IFF3(b) is an international three-factor Fama-French model and uses WHML and WSMB constructed from individual securities.

Figure 3. Weights of Arbitrage Portfolios for IFF3(b)

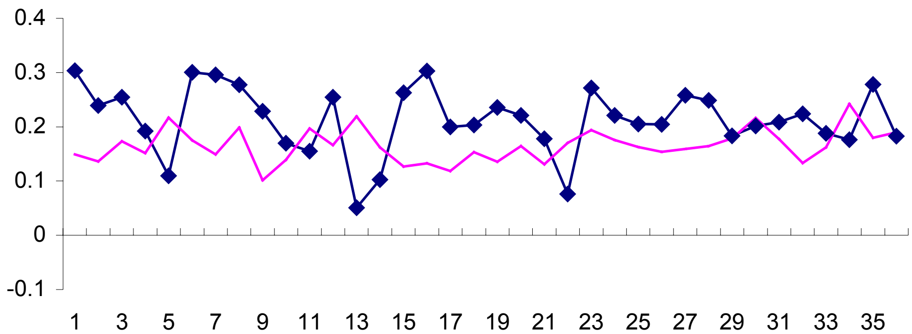




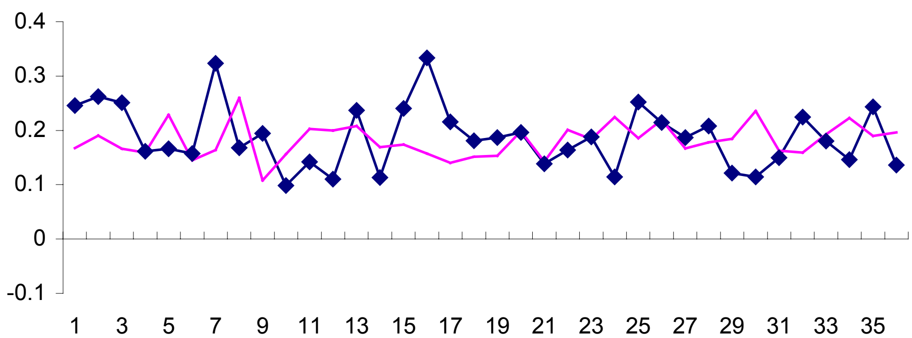
The basic returns are local excess returns of the 36 FT industries. Weekly data are from 1986:01 to 2001:05. Portfolio weights are defined in equation (5) and are standardized to sum to one. IFF3(b) is an international three-factor Fama-French model and uses WHML and WSMB constructed from individual securities.

Figure 4. Summary Statistics of Value Industry Portfolios

EXCESS RETURN (IN %) OF EW-VALUE PORTFOLIO RETURNS



EXCESS RETURN (IN %) OF VW-VALUE PORTFOLIO RETURNS



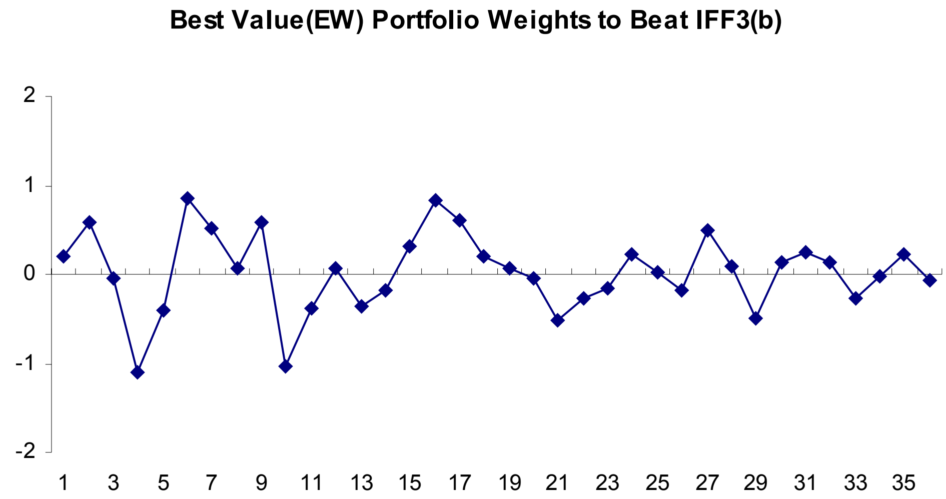
The basic returns are local excess returns of the 36 FTSE industries with high book-to-market ratios. Weekly data are from 1986:01 to 2001:05. The line with the diamonds is the mean returns, and the line without diamonds provides the two standard error band. All numbers are in % per week.

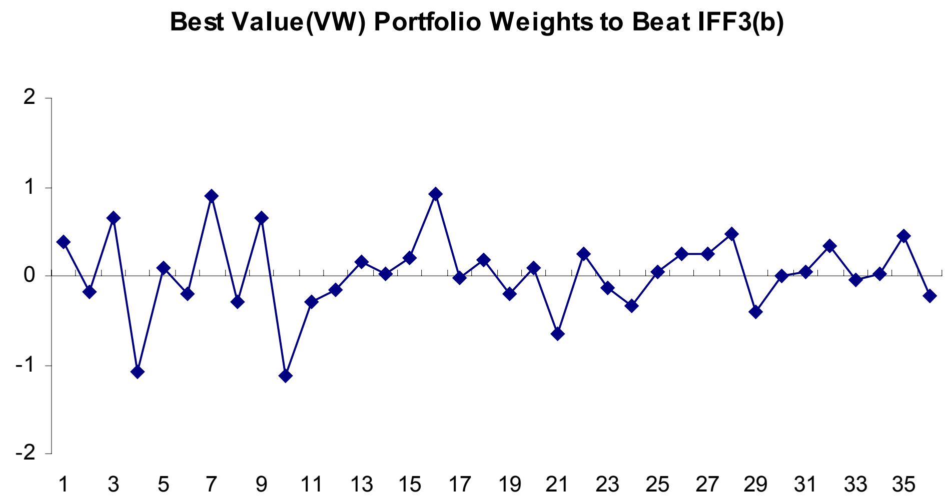
Table 5. Robustness

	ICAPM	ICAPMEX	IFF2(a)	IFF2(b)	IFF3(a)	IFF3(b)
EW returns						
SMALL	0.34	0.37	0.30	0.30	0.28	0.33
BIG	0.65	0.54	0.66	0.68	0.82	0.86
VALUE	0.05	0.03	0.05	0.08	0.12	0.15
GROWTH	0.52	0.55	0.55	0.47	0.74	0.74
VW returns						
SMALL	0.37	0.20	0.34	0.27	0.33	0.35
BIG	0.93	0.94	0.94	0.98	0.99	0.99
VALUE	0.16	0.15	0.18	0.14	0.25	0.26
GROWTH	0.87	0.82	0.87	0.85	0.91	0.93

The test assets are the returns on global industry portfolios sorted by size (market equity) and book-to-market ratio. The panels present the p-values for the test of HJ-distance = 0 using previously estimated parameters derived from minimizing HJ-distance for global industry portfolios without sorting on characteristics. The models are an international CAPM (ICAPM), an international CAPM with exchange risks (ICAPMEX), and two-factor or three factor Fama-French models. IFF2(a) and IFF3(a) use WHML and WSMB constructed from national industry indices; IFF2(b) and IFF3(b) use WHML and WSMB constructed from individual firms.

Figure 5. Weights of Arbitrage Value Industry Portfolios for IFF3(b)





The basic returns are local excess returns of the 36 FT industries. Weekly data are from 1986:01 to 2001:05. Portfolio weights are defined in equation (5) and are standardized to sum to one. IFF3(b) is a three-factor global Fama-French model with WHML and WSMB constructed from individual securities.

Table 6. Diversification Benefits with and without Short-selling Constraint

π: without short-selling constraint					π^S: with short-selling constraint				
Mean	std. dev	p1	p5	median	mean	std. dev	p1	p5	median
0.185	0.037	0.108	0.127	0.183	0.032	0.016	0.003	0.008	0.031

Portfolio weights to achieve π			Portfolio weights to achieve for π^S		
Asset	Mean	Std. err	Asset	Mean	Std. err
benchmark	0.898	0.293	benchmark	0.059	0.145
IND1	0.133	0.334	IND1	0.006	0.030
IND2	0.236	0.301	IND2	0.002	0.017
IND3	-0.182	0.343	IND3	0.016	0.057
IND4	-0.329	0.445	IND4	0.002	0.018
IND5	0.018	0.247	IND5	0.004	0.024
IND6	-0.223	0.488	IND6	0.007	0.043
IND7	0.278	0.649	IND7	0.166	0.168
IND8	-0.100	0.312	IND8	0.005	0.025
IND9	0.210	0.377	IND9	0.079	0.140
IND10	-0.211	0.603	IND10	0.000	0.003
IND11	-0.015	0.264	IND11	0.010	0.042
IND12	0.072	0.247	IND12	0.016	0.047
IND13	-0.021	0.347	IND13	0.020	0.061
IND14	-0.133	0.314	IND14	0.000	0.005
IND15	0.149	0.450	IND15	0.102	0.155
IND16	0.325	0.357	IND16	0.176	0.191
IND17	0.007	0.425	IND17	0.033	0.094
IND18	-0.539	0.544	IND18	0.000	0.003
IND19	0.024	0.390	IND19	0.009	0.044
IND20	0.381	0.366	IND20	0.149	0.132
IND21	-0.005	0.316	IND21	0.009	0.044
IND22	0.076	0.216	IND22	0.005	0.024
IND23	-0.130	0.305	IND23	0.010	0.044
IND24	-0.249	0.397	IND24	0.001	0.012
IND25	0.244	0.380	IND25	0.018	0.063
IND26	0.122	0.403	IND26	0.012	0.041
IND27	0.059	0.407	IND27	0.001	0.013
IND28	-0.016	0.390	IND28	0.000	0.002
IND29	-0.136	0.362	IND29	0.001	0.011
IND30	0.043	0.199	IND30	0.003	0.019
IND31	0.050	0.357	IND31	0.001	0.008
IND32	-0.085	0.475	IND32	0.000	0.009
IND33	0.054	0.407	IND33	0.001	0.013
IND34	-0.102	0.173	IND34	0.004	0.021
IND35	-0.118	0.480	IND35	0.001	0.015
IND36	-0.157	0.509	IND36	0.000	0.003

The first panel present the maximum improvement on Sharpe ratio (π) of the value-weighted global industry portfolio over the benchmark tangency portfolio implied by IFF3(b). The statistics are calculated from 10,000 simulations, where mean is the empirical mean, std. err is the standard deviation, p1 is the value of the measure at 1 percentile, p5 is the value of the measure at 5 percentile, and median is the value of the measure at 50 percentile. Superscript S implies short-selling constraints are imposed. The second panel presents the mean and standard deviation of weights on the portfolios achieving the maximum improvement.