A TEST FOR A MULTI-RISK PREMIA INTERNATIONAL ASSET PRICING MODEL: AN ARBITRAGE PRICING THEORY APPLICATION

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ABSTRACT

In this paper, the authors examine the existence of a multi-risk premia international asset pricing model using an Arbitrage Pricing Theory approach. An international asset pricing model is developed and tested using foreign exchange rate adjusted market indices for twenty-five countries' stock markets for the period January 1964 to December 1980. The authors find evidence that indicates three risk premia exist for pricing mean returns on international assets. A model not adjusted for foreign exchange rate changes does not perform as well as an adjusted model.

I. INTRODUCTION

The object of this research is to apply Ross's [1976] arbitrage pricing model [APT] to explain international asset price changes. Several conclusions could be drawn depending on the results of the empirical work. If no risk premia are found then perhaps the attempts to price assets in an international setting may not be appropriate. If one and only one risk premium is found, then the appropriateness of the single-factor model is supported. If more than one risk premium is found, then the use of a multi-factor model such as the APT should be considered in pricing international assets.

In the following section, relevant research will be reviewed. Since research on the single-factor international asset pricing model reveals the possibility of more than one risk premium, the validity of using an international APT is made evident.

The third section of this paper presents the international APT. The data used and the research design will

also be discussed in this section. Section four will discuss the research results and Section five will present the conclusions and implications of this research.

II. ARBITRAGE PRICING THEORY

Arbitrage pricing theory is based on four assumptions. Given perfectly competitive and frictionless asset markets in which investors believe in a k-factor returns generating model, an asset's random return, $r(i)$, is equal to its expected return, $E(i)$, plus 'k' risk premia and an unsystematic risk component, $e(i)$.

$$r(i) = E(i) + b(i,1)L(1) + \dots +$$

$$b(i,k)L(k) + e(i) \quad [1]$$

Each $b(i,k)L(k)$ is the risk premium associated with that risk component where $b(i,k)$ is the sensitivity of asset 'i' to risk component 'k'. APT assumes that the error terms are not correlated either with the other error terms or with the risk premia. The

model assumes that the number of assets in the market, n , greatly exceeds the number of factors, k .

Given the return generating function in Equation [1], no arbitrage opportunities, and independent error terms, the asset pricing model is

$$E(i) = L(0) + L(1)b(i,1) + \dots + L(k)b(i,k) \quad [2]$$

$E(i)$ is the expected return for asset 'i', $L(0)$ is the return on a riskless asset, and $L(1), \dots, L(k)$ are the risk premia associated with each of the 'k' risk components.

INTERNATIONAL ASSET PRICING

Grubel [1968] first presents the gains from internationally diversified portfolios. For the two country, two asset case he shows that the efficient frontier can be increased by allowing international diversification. Grubel uses monthly returns, adjusted for foreign exchange rate changes, for the period January 1959 through December 1966 for eleven countries. A portfolio composed of investments in all eleven countries dominated all other portfolios.

Brewer [1981] shows that if there is no difference in risk adjusted performance of United States based multinational and national firms, then investors must acquire international assets rather than invest in multinational firms to achieve the benefits of international diversification. Using the Chow test, Brewer finds no statistical difference in the market model parameters for the multinational and national portfolios. Grubel concludes that since the parameters are not different, the security market lines are not different and, therefore, multinational and national firms provide the same benefits to shareholders. This implies that multinational stock may not be an adequate substitute for international assets in the attempt to diversify internationally.

Solnik [1974] develops an equilibrium model of the international capital market assuming that security price behavior is consistent with a single world market concept. Solnik shows that international mutual funds which invested in all common stocks, with market value weights, afford investors of any country international diversification. However, the need for such a fund would occur only if the investor himself could not purchase the world market portfolio.

Agmon [1972] studies the share price co-movement in the United States, West Germany, the United Kingdom, and Japan. He does so to test the relevance of pricing international assets in a one market context. Utilizing a model similar to Solnik's, Agmon estimates the parameters using share price indices and individual share data. Although Agmon does not reject the possibility of a one market model, interesting findings were made. In scrutinizing the results of share price indices, Agmon points out that the United Kingdom and Japan seem to be a specialized subset of the four country market. The results of the individual share data show the possibility that countries tend to specialize in 'producing' capital assets, within a given level of risk, within one multinational equity market. These results indicate that there is a possibility of a multifactor model and that while the United States and West Germany should react differently than the United Kingdom and Japan and each other, Japan and the United Kingdom should react similarly.

Stehle [1977] compares a model which assumes an integrated international market with a model that assumes a segmented market. He decomposes the return of an international asset into three parts; the first is perfectly correlated with the rate of return on the domestic market portfolio, the second component is an international market component uncorrelated

with the rate of return on the domestic market portfolio, and the third component is uncorrelated with the first two. Stehle compares this model with the CAPM to see if assets are priced purely domestically or internationally. Using data on stocks of the New York Stock Exchange from January 1956 to December 1975, Stehle is unable to reject either model in favor of the other. Due to the inconclusiveness of the results, the multiple risk-premia model could not be rejected.

Finnerty and Schneeweis [1979] analyze the comovement of United States stock and bond returns with stock and bond returns for eight other industrialized countries. The countries are West Germany, Italy, The Netherlands, Switzerland, Japan, Belgium, France, and the United Kingdom. Simple correlation coefficients are calculated for returns adjusted and unadjusted for foreign exchange rate changes. The correlations were all low and erratic and Finnerty and Schneeweis state that one explanation for these low correlations could be the reaction of returns to differential risk and return factors. They suggest adjusting returns for foreign exchange movement since these are better indicators of the true return to an investor in a specific country and, thus, would pertain to a different aspect of international equity market rates of return comovement than the unadjusted returns.

In summary, Grubel shows the gains from international diversification. Brewer shows that international assets, rather than United States domiciled MNC's must be held to benefit from international diversification. Both conclusions support the value of international diversification through portfolio investment. Solnik provides a single market model to price international assets while Stehle provides a basis for testing the appropriateness of a multi-factor model. Finnerty and Schneeweis show that, testing an inter-

national model using returns adjusted for foreign exchange rate movements should yield higher explanatory power than unadjusted returns. Agmon indicates that, while testing a multi-factor model, the United States and West Germany do not react the same to risk premia with respect to each other or the United Kingdom and Japan, and the United Kingdom and Japan appear to be a specialized subset of the international capital market.

III. RESEARCH DESIGN

The adaptation of the APT for pricing international assets is straight forward. The international model is the same as the domestic model:

$$R(i) = L(0) + b(i,1)L(1) + \dots + b(i,k)L(k) \quad [3]$$

The only modification necessary is to redefine $L(0)$ as the world return on a zero beta portfolio. Both the linear generating process and the development of the pricing model is the same as the domestic model presented earlier. To be explicit, the definitions of the variables in Equation [3] are:

$R(i)$ = the expected return on asset 'i'.

$L(0)$ = the world return on a zero beta asset.

$L(k)$ = the k (th) world risk premium.

$b(ik)$ = the sensitivity of asset 'i' to world risk premium 'k'

The goal of testing the model is to determine the number of priced risk premia in Equation [3]. To do this, an international data set is used. The data set is industrial share prices and foreign exchange rates for 25 countries taken from the International Monetary Fund, International Financial Statistics data tape. The countries used are Austria, Australia, Belgium, Canada, Chile, Colombia, Finland, France, India, Italy, Japan, Mexico, Netherlands, New Zealand, Norway, Pakistan, Peru, Philippines, Spain, Sweden, Switzerland, United Kingdom, United States, Venezuela, West Germany. Monthly observa-

tions were taken from January 1964 to December 1980 for a total of 204 observations per variable per country.

Prior to testing the model, the raw data are transformed. First, monthly industrial share price changes are calculated for each country. One plus the change in the industrial share price index, $R(ISP)$, is equal to the month end industrial share price index, $ISP(t)$, divided by the beginning of the month industrial share price index, $ISP(t-1)$.

$$(1+R(ISP))=ISP(t)/ISP(t-1) \quad [4]$$

This yields 203 industrial share price relatives for each of the 25 countries. Then, monthly foreign exchange rate changes are calculated for each country. The exchange rate change, $R(FX)$, is equal to the end of the month exchange rate, $FX(t)$, divided by the beginning of the month exchange rate, $FX(t-1)$.

$$(1+R(FX))=FX(t)/FX(t-1) \quad [5]$$

In this manner, 203 foreign exchange rate changes for all 25 countries will be in dollar terms. The assumption is being made that the investor is a United States resident and interested in dollar returns.

Next, the natural log of the returns and exchange rate changes were taken. Since returns are never less than 100%, the distribution of returns is skewed. For further analysis, the distribution should be normal. Since returns are approximately log normal, this transformation is used.

The two return sets, the natural log of foreign exchange rate changes and the natural log of industrial share price index changes are added for each country for each month. The APT analysis is performed on this time series: the natural log of the industrial share price indices, adjusted for foreign exchange rate changes.

To determine the appropriate number of risk premia, a research design similar to Roll and Ross [1980] is used. First, factor analysis, with varimax rotation, is performed to determine the sensitivity components of the model, $b(i,k)$. The number of factors extracted is determined by allowing factors with given values of one or more to be included [Kryzanowski and To, 1983].

Once the number of factors is determined, generalized least squares multiple regression is performed. The dependent variable of the regression, $R(i,t)$, is the mean monthly change for each industrial share price index. The independent variables, $b(i,k)$, are the factor loadings for each month for each index.

$$R(i,t)=L(0)+b(i,1)L(1)+\dots+b(i,8) \\ L(8) \quad [6]$$

This regression determines the number of risk premia that are statistically significantly related to changes in the exchange rate adjusted industrial share price indices.

IV. EMPIRICAL RESULTS

The results of the factor analysis are presented in Table 1. Countries are grouped with each factor for which the country has a factor loading greater than 0.40. These results indicate the number of factors and the factor to which each country is most sensitive.

Belgium, West Germany, The Netherlands, and Switzerland are most sensitive to the same factor. The United Kingdom and Spain consistently group together. These groupings suggest a segmentation of markets which is not simply geographic. Eight factors are extracted from the adjusted industrial share price data.

The results of the industrial share

price data adjusted for foreign exchange rate changes support Agmon's contentions. West Germany is sensitive to factor one, and, while grouped with seven other countries, it is not grouped with the United Kingdom, the United States, or Japan. The United States is most sensitive to factor two, and, while grouped with four other countries, none is the United Kingdom, Japan, or West Germany. Finally, the

United Kingdom and Japan are most sensitive to factor three, and, while grouped with four other countries, none of them is the United States or West Germany. This supports the contention that the United Kingdom and Japan are a specialize subset of the four countries, the United States, the United Kingdom, West Germany, and Japan.

Table 2 presents the proportion of

Table 1
Factor Analysis Results
Industrial Share Prices
Adjusted for Foreign Exchange Rates

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Factor 1	Austria	.71
	Belgium	.69
	Finland	.42
	France	.41
	India	.45
	Netherlands	.75
	Norway	.46
	Switzerland	.71
	West Germany	.75
Factor 2	Australia	.49
	Canada	.84
	France	.44
	Sweden	.46
	United States	.70
Factor 3	Australia	.43
	Japan	.42
	New Zealand	.46
	Philippines	.55
	Spain	.81
	United Kingdom	.60
Factor 4	Italy	.55
	Mexico	.82
Factor 5	Columbia	.71
	Venezuela	-.68
Factor 6	Finland	.45
	Peru	.74
Factor 7	Pakistan	.74
Factor 8	Chile	.90

Table 2
Explained Variance (%) of Each Factor Analysis
Marginal and Cumulative

Industrial Share Prices (Adjusted)	
Marginal	Cumulative
16.7	16.7
10.3	27.0
10.1	37.1
5.4	42.5
5.0	47.5
4.7	52.2
4.7	56.9
4.3	61.2

Table 3
Cross-Sectional Regression Results
Industrial Share Prices (Adjusted)

Model

$$R(i) = L(0) + b(i,1)L(1) + \dots + b(i,8)L(8)$$

Factor	Coefficient	T-value	Significance Level
1	0.0100	2.22	0.05
2	0.0099	2.05	0.05
3	0.0072	1.55	0.15
4	0.0054	0.92	0.35
5	0.0110	1.84	0.10
6	0.0076	1.30	0.20
7	0.0102	1.51	0.15
8	-0.0207	3.29	0.01

explained variation attributable to each factor. The marginal explained variation for the first three factors using adjusted returns is 37.1%. The cumulative explained variation for all eight factors is 61.2%.

Table 3 contains the results of the GLS regressions run between the monthly industrial share price index changes and the factor scores. The number of risk premia which are statistically significant in explaining the price changes, at the five percent level is three: factors one, two, and eight. The other five factors are not statistically significant in explaining price changes.

V. CONCLUSIONS

This study provides evidence which indicates that a multi-risk premia model should be used to price mean returns on international assets. Specifically, three priced risk-premia are found in the model to explain mean industrial share price returns adjusted for foreign exchange rate changes. International returns should

be adjusted for foreign exchange rate movement since doing so increases the explanatory power of the model. This confirms the conclusion of Finnerty and Schneeweis.

Agmon's contention that the United Kingdom and Japan are a specialized subset of the international capital market is supported. The United Kingdom and Japan are both most sensitive to factor three in the factor analysis results using adjusted industrial share price changes. West Germany and the United States are most sensitive to factors one and two respectively, but not sensitive to factor three.

While the single factor model to price international assets may encompass multi-risk premia, the results of this study indicate that there is more than a single world market risk premium. Further research in this direction should be directed toward finding a method of analysis to determine empirically the nature and identification of these risk premia.

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