

INSTITUTO TECNOLÓGICO
Y DE ESTUDIOS SUPERIORES DE
MONTERREY

EGADE



WHAT EXPLAINS THE RETURNS IN THE
MEXICAN STOCK MARKET?

DOCTORAL DISSERTATION

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Monterrey, N.L.; November, 1999

**WHAT EXPLAINS THE RETURNS IN THE MEXICAN
STOCK MARKET?**

by

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Dissertation

Presented to the Faculty of the Graduate School of Business Administration

and Leadership (EGADE) of

the Instituto Tecnológico y de Estudios Superiores de Monterrey

in Partial Fulfillment of the Requirements

for the Degree of

Doctor of Philosophy

in

Management

Instituto Tecnológico y de Estudios Superiores de Monterrey

November, 1999

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DEDICATION

TO DIANA, ANDREA, AND RODOLFO

ACKNOWLEDGEMENTS

This dissertation would not be possible without the wise advice, encouragement, and friendship of my committee: Laura T. Starks, Alejandro Ibarra and Martin Herrera. Their comments, revisions, additions, and corrections forced me to give my best. I would like to add special thanks to my principal advisor, Dr. Starks. In addition to providing guidance for my proposal, Dr. Starks supported me in many ways during my stay at The University of Texas during the 1997-1998 academic year. To Dr. Ibarra for providing me with his support during the 1996-1997 academic year in Monterrey and all his advice in the use and application of quantitative methods. To Dr. Herrera for his support in data base performance and his careful revision of the implementation of the experiment and his continuous discussions. A special thanks to my friend Richard Mehl who always encouraged me to never stop and helped me by correcting and editing the writing of this document. Finally, I want to thank all my colleagues at The University of Texas at Austin, ITESM-Monterrey, and ITESM-Guadalajara.

Especially important was the financial support from the “Consejo Nacional de Ciencia y Tecnología” (CONACYT) and the ITESM, my sponsors during the program. I want to thank particularly Dr. Jaime Alonso Gómez, Dra. María Lourdes Dieck, Lic. Juan Carlos Enríquez, and Ing. Juan Manuel Durán who have always believed in me and encouraged my efforts.

ABSTRACT OF DISSERTATION

GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP,
INSTITUTO TECNOLÓGICO Y DE ESTUDIOS SUPERIORES DE
MONTERREY, CAMPUS MONTERREY

Degree: Doctor of Philosophy Program: Doctoral Program in Administration

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Title: **WHAT EXPLAINS THE RETURNS IN THE MEXICAN STOCK
MARKET?**

The main objective of this paper is to develop an asset pricing model for the Mexican stock market during the period of July 1989 to December 1998. Asset pricing theory has been a topic of debate in the United States for over thirty years and consensus has not been reached. Pursuit of empirical research in pricing models is a priority in order to increase knowledge of how the market functions and to improve market regulations. Empirical research of the Mexican financial markets is scarce. The results presented in this paper suggest that the CAPM is rejected and a five-factor model is not rejected. The factors are: market index, size, book-to-market equity ratio, momentum, and peso/dollar exchange rate. The results are robust to: the use of returns in dollars or pesos; the inclusion or exclusion of the December 1994 devaluation and the economic after-shock; and the use of value-weighted or equally-weighted market indices. This may be the first study using the mimicking factor

approach to describe exchange rate risk. The exchange rate is also tested using the traditional macroeconomic variables as factors technique. With both techniques the beta-loadings are significant and the premium is positive and statistically significant. It is important to find if the beta-loading or the characteristic per se of the factors explain the returns. However, the low number of stocks in the Mexican stock market did not allow the test to clearly discriminate between the beta-loading or the characteristic. This dissertation opens lines of future research in portfolio evaluation, event studies, and corporate finance. The results indicate that additional investigation is required to discriminate between factor beta-loading or characteristics.

Subject Category: Finance 0508, Finance 0277

Key words: Capital Asset Pricing Models, Multifactor Models, Foreign Exchange Rate Risk, Emerging Markets, Mexico.

RESUMEN

ESCUELA DE GRADUADOS EN ADMINISTRACIÓN Y DIRECCIÓN DE EMPRESAS, INSTITUTO TECNOLÓGICO Y DE ESTUDIOS SUPERIORES DE MONTERREY, CAMPUS MONTERREY

Grado: Doctor en Filosofía Programa: Programa Doctoral en Administración

Nombre del Candidato: Mauricio Cervantes Zepeda

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Título: **¿QUE EXPLICA LOS RENDIMIENTOS DEL MERCADO DE ACCIONES EN MEXICO?**

El principal objetivo de esta disertación, es desarrollar un modelo de valuación de activos de capital para el mercado mexicano de acciones, durante el período de julio 1989 a diciembre de 1998. Desde hace más de treinta años la teoría de valuación de títulos financieros ha sido un tópico de debate en los Estados Unidos y aún no se ha alcanzado consenso. Esto se debe a que la investigación en modelos de valuación es una prioridad para incrementar el conocimiento sobre el funcionamiento del mercado y mejorar las regulaciones del mismo. Sin embargo, en México la investigación empírica en los mercados financieros ha sido escasa. Los resultados encontrados en la presente disertación sugieren que el CAPM es rechazado y un modelo de cinco factores no es rechazado. Los factores son: un índice del mercado, tamaño, valor libros/valor mercado, momento, y tipo de cambio peso/dólar. Estos resultados son robustos al uso de los rendimientos en dólares o pesos; a la inclusión o

exclusión de la devaluación de diciembre de 1994 y su subsiguiente choque económico y al uso de un índice de mercado con promedios ponderados o igualmente balanceados. Posiblemente éste sea el primer estudio usando la técnica de factores mímicos que describen el tipo de cambio como factor de riesgo. El tipo de cambio también es probado usando la técnica tradicional de factores con variables macro-económicas. En ambas técnicas las betas son significativas y el premio es positivo y estadísticamente significativo. Es importante encontrar si la beta o la característica en sí de cada factor explica los rendimientos. Sin embargo, debido al reducido número de emisiones en la Bolsa Mexicana de Valores, no es posible discriminar claramente entre la beta o la característica. La presente disertación abre avenidas para futuras investigaciones en valuación de portafolios, estudios de eventos, y finanzas corporativas. Los resultados indican que se requiere más investigación para discriminar si la beta o bien la característica en sí de cada factor explica los rendimientos.

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CHAPTER 1

INTRODUCTION AND OBJECTIVES OF THE RESEARCH

I. INTRODUCTION

The goal of this paper is to form an asset pricing model that describes the behavior of the Mexican stock market. This is not an easy task. Since the appearance of the first pricing model in 1964, empirical tests in the U.S. market have rejected the different approaches proposed. However, recent improved pricing models provide a satisfactory description of stock return variation. The rejection of a pricing model is sensitive to the econometric method and tests that are used. The development of statistical and quantitative methods applied to financial fields has grown considerably in the last decade, developing important tools for the empirical financial researcher.

Mexico's stock market history can be traced to the late 1800's. The development of the market was limited due to the Mexican revolution, World War II, and the strength of the Mexican banking system. Since 1975 several regulation changes, beginning with the consolidation of the three existing Mexican stock markets, the creation of the mutual fund industry, the introduction of electronic trading systems, the private pension fund system, and the derivatives market are converting the Mexican securities market into an emerging modern market. Currently, several Mexican issues are traded abroad, and international companies such as Merrill Lynch, Goldman Sachs, and Bankers Trust are members of the exchange. Thirty-five

percent of the investors in the Mexican securities market are foreign investors (Annual Facts and Figures, BMV, 1998). Given the recent development of the financial market, a weak point of the Mexican securities market is the scarcity of formal research. This is possible due to the lack of useable databases and the small number of qualified researchers specializing in the field.

The study of an asset pricing model is important to the understanding of how investors perceive risk and how economic policy, international events, or firm characteristics affect stock prices. A pricing model could shed light on regulatory questions and be a keystone in the development of portfolio performance theory and research in corporate finance studies. Empirical research can provide a more formal guide to regulatory changes.

II. OBJECTIVES AND HYPOTHESES

In this section the general objective, specific objectives, and the main hypotheses that drive the investigation are described.

a. General Objective

The general objective of this paper is to develop an asset pricing model for the Mexican capital asset market. An asset pricing model describes the risk factors that explain the behavior of stock returns. It aids in understanding trading and identifies the important characteristics that influence investors. A pricing model that explains the cross-section variation of the Mexican stock market would be a useful tool to

evaluate portfolio performance, to analyze event studies, to evaluate projects, to calculate optimal investment options, and to apply to other corporate finance functions.

b. Specific Objectives

This dissertation studies the complete Mexican stock market during the period of July 1989 to December 1998. There are four specific objectives:

- Prove Sharpe's (1964) CAPM as applied to the Mexican stock market.
- Test Carhart's (1997) four-factor model on the Mexican stock market.
- Examine whether the peso/dollar exchange rate fluctuation is a risk factor in the Mexican market.
- Based on the work of Daniel and Titman (1997), an attempt is made to test whether the risk factors or the characteristic per se is the best predictor of Mexican stock returns.

c. Hypotheses

Several hypotheses are developed and tested during the research. The basic assumptions behind the hypotheses are the following: between Mexico and the U.S. numerous barriers such as cultural shock, information-related frictions, legal restrictions, transaction costs, political risk, and exchange risk exist. Despite the barriers, the influence of the U.S. has grown due to increased trading and membership of U.S. firms in the Mexican securities market. Total foreign investment amounts to

35 percent of the market equity. The assumption is that Mexico and the U.S. markets are neither totally segmented nor fully integrated, but instead are partially integrated.

HYPOTHESIS 1: The Sharpe CAPM is rejected in the Mexican stock market.

HYPOTHESIS 2: The four-factors that help explain stock return variation in the U.S. market: market index, market equity size, book equity-to-market equity ratio and momentum, are significant in the Mexican market.

HYPOTHESIS 3: Peso/Dollar exchange rate fluctuation is a source of risk in the Mexican stock market. It is a factor that helps to explain returns and it is priced.

HYPOTHESIS 4: In December 1994, Mexico suffered a currency devaluation and economic shock. The pricing model developed in this dissertation is robust to the inclusion or exclusion of the effects of the devaluation.

HYPOTHESIS 5: Each factor must provide its own information to the model and the factors should be serially uncorrelated. A VAR model that includes all the factors of the pricing model should be statistically insignificant in all the leads and lags.

HYPOTHESIS 6: It is expected that in Mexican stock market the characteristic describes the stock returns better than the factor beta-loading.

The previously stated hypotheses guide the research approach detailed in the methodology section.

III. MAIN CONTRIBUTIONS AND LIMITATIONS

In highly developed and industrialized countries, their capital markets are a driving force in the economy. Because of the influence of these markets, the majority of academic research has centered on them. Numerous asset pricing models have been developed and applied to the major markets, but in countries with emerging capital markets, the understanding of market functioning is not clear. It is essential to perform research in these countries. The development of an asset pricing model is a fundamental step in understanding the relationship between risk and returns. How do investors perceive risk? How adverse are they to risk? Is risk perceived and priced as uni-dimensional or multi-dimensional? Which characteristics are good proxies for risk? In addition to providing a better understanding of the questions listed above, an asset pricing model is indispensable in other areas of finance. Portfolio evaluation requires an assessment of risk and returns. Corporate finance requires a pricing model to determine correct discount rates and optimum investment levels. Event studies require a benchmark to analyze before and after returns.

The main limitation to the study of the Mexican stock market is the low number of firms and the somewhat limited historical data. These conditions limit the use of some techniques that are applicable in larger markets that have extensive historical data and hundreds or thousands of firms. These conditions also constraint the robustness of the results. However, it is important that practitioners, academicians, and regulators in Mexico understand the specific behavior of the Mexican market. This research is designed to contribute to understanding that specific behavior.

IV. ORGANIZATION OF THE DISSERTATION

Chapter 2 explains the evolution of the pricing model from the Sharpe (1964) model to the characteristic-based model of Daniel and Titman (1997). The main anomalies of the Sharpe's Capital Asset Pricing Model (CAPM) are reviewed along with the model's influence on the development of the intertemporal model of Merton (1973) and the arbitrage model of Ross (1976). A discussion of advantages and disadvantages of the different approaches concludes the chapter. Chapter 3 briefly reviews the history of the Mexican stock exchange and describes the basic framework of trading systems, market indices, and availability of information. The linkage of the securities market with the Mexican financial system and important regulations are described. Further, Chapter 3 contains a summary of previous financial empirical research conducted on the Mexican market along with a summary of international research where several countries, including Mexico, are compared. Chapter 4 describes the methods and tests used to perform empirical research in pricing models.

Chapter 5 presents the methodology and results obtained in this dissertation. Finally, summary and future research possibilities are presented in Chapter 6.

CHAPTER 2
CAPM, MULTIFACTOR, AND CHARACTERISTICS
ASSET PRICING MODELS

I. INTRODUCTION

Despite an early attempt by Bernoulli (1783/1954) to define a mathematical measure of risk in terms of probabilities, the twin concepts of expected return and risk have not been fully integrated. Von Neumann and Morgenstern (1947) developed the breakthrough in theoretical choice under uncertainty, but it took the developments of Markowitz (1952), and Tobin (1958) to provide a basis to solve the portfolio selection problem. Markowitz developed an analysis based on maximization of the investor's expected utility and proposed a general solution for the portfolio selection problem. He rejected the rule of maximization of discounted expected returns, showing that under this rule the investors would place all their wealth in the security with the highest expected return. Markowitz's approach to portfolio selection may be characterized as normative.

Six years later, Tobin (1958) attacked the problem of liquidity preference based on tools developed by Markowitz (1952). He showed that under certain conditions Markowitz's model implies that the process of investment choice can be broken-down into phases: first, the choice of a unique optimum combination of risky assets; and second, a separate choice concerning the allocation of funds between such a

combination and a single riskless asset. An additional six years were required before the theory of capital markets appeared. The delay was possibly due to the lack of reality of the assumption required to found it, principally the homogeneity of investor expectations, which Sharpe (1964) emphasized as a necessary step to obtain equilibrium conditions in the capital market. At that time, there was no theory describing how the pricing of securities results from the basic influence of investor's preferences and the physical attributes of capital assets. Without such a theory, it was a difficult task to give any real meaning to the relationship between the price of a single asset and its associated risk. Until 1964, no one had succeeded in constructing a market equilibrium theory of asset price under conditions of risk. In this chapter, the Capital Asset Pricing Model (CAPM), Multifactor, and Characteristics asset pricing models will be briefly reviewed.

Section II briefly reviews the first pricing model, the CAPM of Sharpe (1964), Lintner (1965), and Mossin (1966). In addition, several anomalies have been reported by empirical studies and a brief description of the anomalies is presented. Section III reviews some of the multifactor pricing models. Section IV summarizes the Characteristic-Pricing model developed by Daniel and Titman (1997) that is designed to rectify the limitations usually tied to the other models. Finally, empirical evidence comparing multifactor and characteristic based pricing models is presented.

The goal of this paper is the formation of a pricing model that describes the behavior of the Mexican stock market. Special attention is directed to foreign

exchange rate risk. Section V presents a review of the theory and empirical research behind the exchange rate risk. Finally, conclusions are discussed.

II. THE CAPM AND ITS RELATED ANOMALIES

The origin of the CAPM usually is credited to three authors, Sharpe (1964), Lintner (1965) and Mossin (1966), who independently reached it virtually at the same time. (For a more complete review of portfolio theory see Constantinides and Malliaris, 1995).

Sharpe (1964) gives a verbal-diagrammatic discussion of the determination of asset prices in quasi-dynamic terms, but his lack of precision in the specification of equilibrium conditions leaves parts of his arguments somewhat undefined. Lintner (1965) sent his article to the printers before Sharpe's article was published. His first section is quite similar in form and conclusion to Sharpe's, but he developed an original algebraic framework and included a discussion about the capital budgeting problem. As does Sharpe, he assumes a risk free asset, free transaction costs, equal active and passive interest rates, and investor risk-aversion. One year later, Mossin (1966), developed a similar model.

The need for the existence of a risk-free asset is a limitation of the CAPM. In order to overcome this limitation, Black (1972) derived a less restrictive version of the CAPM. In his model he used the fact that all of the efficient sets of portfolios could be formed as a linear combination of any two efficient portfolios. This version of the CAPM does not depend on the existence of a risk free asset. However, the

basic assumption that all investors have a common joint probability distribution for returns on the available assets is still applied.

A large amount of empirical research has found persistent cross-sectional and time series patterns or anomalies in returns. The anomalies are not explained by the CAPM and it is important to remember that these anomalies reject the null hypothesis that the market is efficient and that the pricing equilibrium model is correct. Concluding that the market is inefficient may be incorrect since the rejection could be due to a test based on an incorrect pricing model. The fact that such anomalies have persisted for periods longer than thirty years suggests that the problem may be an inadequate equilibrium model. Some of the most relevant anomalies found in the last years will be mentioned and for a more complete description see Hawawini and Keim (1995).

Banz (1981) documents the importance of the firm size (market capitalization of a common equity) for the period of 1931-1975. Regressing the returns by using beta and the firm size, his results show that the statistical association between returns and size is negative and strongly significant and the explanatory power of the beta is very low. Basu (1977) demonstrates that the price-earnings ratio (P/E) has more powerful explanatory power than the CAPM beta. He suggests that P/E ratios may explain the violations of the CAPM and concludes that there is a significant negative relation between P/E and average returns in excess of those predicted by the CAPM. By using the annual rankings during the period 1957-1975 he shows that buying the quintile of lowest P/E and selling short the highest P/E quintile, the average annual

abnormal return would have been 6.75% gross. Stattman (1980) documents a significant negative relationship between the price per share to book value per share (P/B) and returns. The average monthly difference of the extreme P/B portfolios, for the 1962-1989 period, is comparable to the differential of P/E and larger than the size premium measured over the same period. The P/B ratio is equivalent to the inverse of the book equity-to-market equity ratio (BE/ME). Bhandari (1988) documented a positive relationship between leverage and returns.

In addition, there are time series related anomalies in many models. One of the first studies to report time series anomalies is Fama and French (1988). The study suggests negative serial correlation in periods of three to five years. Lo and MacKinley (1988) report positive serial correlation in weekly returns, but the findings were considered economically insignificant. Jegadeesh (1990) regressed excess returns on the last 12, 24, and 36 month periods for the 1934-1987 period. He found that the one and twelve month lags are particularly high and significant at the one percent level. Later, Jegadeesh, and Titman (1993) found trading strategies, such as buying past winners and selling past losers (3 to 12 months), that realized significant abnormal returns over the 1965-1989 period. They suggest that this result is not due to additional risk or lead-lag effects from reaction to common factors, but is consistent with delayed price reactions to firm-specific information. After one year the excess returns begin to dissipate. Rouwenhorst (1998) obtains very similar results to Jegadeesh and Titman in a sample of 12 European countries over the period from 1980 to 1995. Hong, Lim, and Stein (1999) suggest that heterogeneity across

investors, who observe different pieces of private information at different points in time, explains momentum. They assume that information diffuses gradually across the investing public and investors cannot perform the rational-expectations trick of extracting information from prices. Momentum reflects the gradual diffusion of firm-specific information.

While there is some agreement that value strategies have produced returns superior to growth strategies, the interpretation of why this has occurred is more controversial. Basically, there are three lines of explanation for these anomalies: missing risk factor or multidimensional risk; psychological investor reaction, and methodological problems. In line with multidimensional risk, several models have been developed. The most remarkable are the Intertemporal Capital Asset Pricing Model (ICAPM) by Merton (1973) and the Arbitrage Pricing Theory (APT) by Ross (1976). In this approach Fama and French (1992, 1993) argue that CAPM related anomalies are the result of additional risk and that additional factors should be included in the pricing model. Then, investors are fully rational, but they price risk in a multidimensional framework. Haugen (1994), DeBondt and Thaler (1995), and Lakonishok, Shleifer, and Vishny (1994) argue that naive strategies might be extrapolated: past earnings growth is extended too far and investors overreact to good or bad news. Consequently, the naive investor overprices growth stocks and undervalues the value stock. Low BE/ME ratio (or growth) stocks are more glamorous, attracting naive investors who push up prices and lower the expected returns. The authors suggest that contrarian investors bet against such naive investors

and outperform the market. This hypothesis implies that there are more naive investors than contrarian investors and the market would not be efficient or offer a lot of virtual arbitrage opportunities. Otherwise, Haugen (1994) proposes an explanation based on agency problems. Although portfolio managers are aware that value stocks have bigger expected returns, they feel more comfortable buying growth stocks. For instance, who would fire a manager or sue a broker who bought the stock of IBM or Microsoft?

The motivation behind the contrarian strategy of Lakonishok et al. (1994) is quite different from the Jegadeesh and Titman (1993) momentum strategy. Momentum-based strategies rely on the market's short-term failure to recognize a trend. In contrast, the superior returns due to value strategies documented by Lakonishok et al., seem to be driven by the market's unwarranted belief in the continuation of a long-term trend and the gradual abandonment of that belief.

However, consensus has not been reached on this point. Disagreeing with the Lakonishok et al. hypothesis, Fama and French (1996) do not accept that value strategy verges on being an arbitrage opportunity. They show that the risk premium and standard deviation for betas, size, and value strategies were 5.9, 4.2, and 6.3 (return premium) and 16.3, 14.4, and 13.1 (standard deviation), respectively, during the period of 1964-1993. They also point out that the value strategy had negative returns for ten years that were similar to the returns of the CAPM model. The argument is that these findings are consistent with the factor risk hypothesis. However, MacKinlay (1995) suggests that the statistical distribution of the ex ante

Sharpe ratio from the returns of Fama and French (1993) portfolios is too high to be explained within the context of efficient-market theory.

Another explanation of the CAPM anomalies is by Kothari, Shanken, and Sloan (1995). They argue that CAPM does not provide explicit guidance on the choice of a horizon in assessing whether beta explains cross-sectional variation. The choice of monthly returns is largely a consequence of data availability and the inference can be sensitive to the interval used to estimate betas because true betas themselves vary systematically and nonlinearly with the length of the interval. Kothari et al. estimate betas from the time-series of annual portfolio returns on the equally-weighted market index. Their results reveal an economically and statistically significant premium (about six to nine percent per annum) for beta risk which is not influenced by the portfolio-formation (they repeat Fama and French (1993) procedures). Further, they found that the BE/ME and returns are weaker and less consistent than in Fama and French. They conjecture that this could be due to COMPUSTAT selection bias but can only provide indirect evidence. Kothari et al. present reasons for using annual data, such as problems in beta estimates due to trading frictions and non-synchronous trading, or problems in inducing systematic cross-temporal covariance in short-interval returns. They suggest that using longer interval returns mitigate these biases. Kothari et al. suggest that an alternative approach to reduce bias in beta estimates could be the estimation of the beta as the sum of the slopes in the regression of a portfolio's monthly return on the current and prior month's market return. There appears to be a significant seasonal component to monthly returns, and the use of

annual returns is one way, although not necessarily the best, to minimize the statistical complications that occur from seasonality. Empirically, the betas of small firms increase and those of large firms decrease with the return-measurement interval. Kothari et al. found that the size effect was substantially reduced when annual returns are employed.

Most empirical studies of the static CAPM assume that betas remain constant over time and the return on the value-weighted portfolio of all stocks is a proxy for the return on aggregate wealth. In another attempt to explain the CAPM anomalies, Jagannathan and Wang (1996) propose that these anomalies are induced because the relative risk of a firm's cash flow is likely to vary over the business cycle. Hence, betas and expected returns will in general depend on the nature of the information available at any point in time and will vary. The argument is that econometricians who ignore the time variation of beta will mistakenly conclude that the CAPM does not hold. They will find a flat relationship between betas and returns as Fama and French (1992) did. However, Ghysels (1998) suggests that trying to capture the time variation betas could be inherently misspecified. He argues that there is a real possibility that serious pricing errors can be committed, potentially larger than with a traditional constant beta model. His results suggest that this is indeed the case, namely that pricing errors with traditional constant beta models are smaller than with conditional CAPMs. Agreement or a consensus of opinion on the argument has not been achieved.

III. THE MULTIFACTOR MODELS

Empirical research in the last twenty years has rejected the joint hypothesis of market efficiency and CAPM, encouraging the development of multi-factor alternative models. Merton (1973) and Ross (1976) have been the pioneers in the development of multifactor models.

The ICAPM by Merton (1973), shows that investors will share out with the riskless asset the tangency portfolio in the mean-variance curve (not necessarily the market portfolio) and a hedging portfolio, with the weights being dependent on investor preference. A hedging portfolio (or portfolios) will depend on the correlation of the assets with the possible state or macro variables. The ICAPM has the simplicity and empirical tractability of the CAPM. It is consistent with the expected utility maximization and provides specification of the relationship among yields that is more consistent with existing empirical evidence. The model, however, has weaknesses. It uses homogeneous expectations plus the assumption that trading in assets takes place continually in time and returns are log-normally distributed. Nevertheless, ICAPM is robust enough in the sense that it can be extended to include effects other than shifts in the investment opportunity set.

Ross (1976) created the Arbitrage Pricing Theory (APT). The idea behind the model is that equilibrium market prices should be rational in the sense that prices will move to rule out arbitrage opportunities. Furthermore, the APT yields an expected return-beta relationship, using a well-diversified portfolio that can be constructed from any large number of securities and avoids the unobservable market portfolio.

The APT implies that this relationship holds for all but perhaps a small number of securities, focusing on the no-arbitrage condition. Without the further assumptions of the CAPM, the APT cannot rule out a violation of the expected return-beta relationship for any particular asset.

In the APT, some agents could disagree on the distribution of the idiosyncratic noise term, e . There is also a possible weak assumption that all the individual noise terms are mutually uncorrelated. However, APT still requires essentially identical expectations and agreement on the beta-loadings as explanatory variables if the identification of ex ante beliefs with ex post realizations is to provide empirically useful results.

Grinblatt and Titman (1983) present a derivation of the factor pricing equation that describes the deviation on an asset by asset basis. The deviation is shown to be small for assets in a realistic finite economy and is arbitrarily close to zero for those assets with arbitrarily small size relative to aggregate wealth. This means that the linear multifactor equation provides a good approximation for the mean returns of all traded assets.

Grinblatt and Titman (1987) introduced some extensions of efficient-set mathematics and offered an intuitive interpretation of the APT model showing that there is an important distinction between the implication of mean-variance efficiency in the CAPM and local mean-variance efficiency in the APT. While the CAPM predicts that the market portfolio is mean-variance efficient, it does not give clues about which portfolios are mean-variance efficient in observable subsets of the

economy. Grinblatt and Titman demonstrate that the APT predicts that for subsets of the economy's assets, the proxy portfolios of factor analysis are locally mean-variance efficient. It also predicts that in any subsets of the overall market, large diverse portfolios approach local mean-variance efficiency as the number of securities becomes large. The APT is inherently more testable than the CAPM since the test does not rely on the observation of particular indexes. Grinblatt and Titman do not provide new techniques to test the APT or other multifactor equilibrium models, but provide a fresh approach for interpreting some difficulties encountered in research on these models.

One of the first empirical studies of a multifactor model is Fama and French (1992). They analyzed the size effect of Banz (1981), the positive relationship between leverage and returns documented by Bhandari (1988), a BE/ME anomaly of Stattman (1980), and E/P of Basu (1983) by regressing the stock returns on all these variables. Their results suggested that beta does not seem to help to explain the cross-section of average returns, and the combination of size and BE/ME equity seems to absorb the roles of leverage and E/P in average returns, at least during their 1963-1990 sample period. If assets are priced rationally, Fama and French (1992) results suggest that stock risk is multidimensional. One risk dimension is mimicked by size and another by BE/ME. It is possible that the BE/ME captures the relative distress risk factor. They conclude that two easily measured variables, size and BE/ME, provided a simple and powerful representation of the cross-section of average returns for the 1963-1990 period.

Fama and French (1993) expanded their research to include U.S. government and corporate bonds and identified five common risk factors in the returns on stocks and bonds. In Fama and French (1992), size and BE/ME explain the cross-sectional variation, but in time series analysis Fama and French (1993) found that these variables alone cannot explain the large difference between the average returns on stocks and one-month T-bills. In order to analyze excess returns, a market factor is necessary. Fama and French (1993) created two portfolios, based on sorting by size and BE/ME, mimicking the size risk factor or small-minus-big portfolio (SMB), and the BE/ME risk factor high-minus-low portfolio (HML). Thus, SMB is the difference between the returns on small-and big-stock portfolios with about the same weighted-average BE/ME equity. This difference should be largely free of influence of BE/ME, focusing instead on the different return behaviors of small and big stocks. Similarly the HML portfolio returns should be largely free of the size factor, focusing instead on the different return behaviors of high-and-low BE/ME firms. However, the hypothesis that these three factors completely explain the returns, (regression intercepts are equal to zero), was rejected. Fama and French explain that the rejection comes largely from the lowest BE/ME quintile of stocks, and despite its marginal rejection, the authors believe that the three-factor model does a good job on the cross-section of average stocks. Besides, they explain that their model also captures the reversal of long term returns but recognize that their three-factor model is just a model and cannot explain the continuation of short-term returns or momentum. Fama and French (1993) suggest that one of the state variables could be related to relative

distress. One necessary condition for multifactor ICAPM or APT is multiple common sources of variance, and they show that there is indeed strong covariation in returns that are not captured by the market return.

Another multifactor approach is the conditional CAPM by Jagannathan and Wang (1996). The model is very different from the typical CAPM and very similar to the APT and ICAPM. They show how a one factor conditional CAPM leads to a two-factor and three-factor model of unconditional expected returns. The conditional CAPM has an undesirable feature in that econometricians have to take a stand on the nature of the information available to investors. Also, since a number of events occur at predetermined monthly and yearly frequencies, one strategy would be to use annual data over a long period. The problem is that over long periods, the economy is not stationary. Connor and Korajczyk (1995) present a detailed review of the different versions of multifactor models.

IV. THE CHARACTERISTIC-PRICING MODEL

Multifactor pricing models have been proposed as an alternative to the CAPM. However, MacKinlay (1995) suggests that multifactor models do not explain the CAPM related anomalies and that examining other alternatives may be fruitful. He shows that the evidence against the CAPM could also be interpreted as evidence that multifactor models on their own cannot explain the deviation of the CAPM. His results suggest that more can be learned by considering the likelihood of various existing empirical results using different economic models.

Daniel and Titman (1997) address the question of whether the return patterns of characteristic-sorted portfolios (i.e. SMB and HML portfolios) are, in fact, consistent with a factor model. They question whether there are pervasive factors that are associated with size and BE/ME and whether there are risk premia associated with these factors. They tested whether the high returns of small size and high BE/ME can be attributed to factor beta-loading. They found that there is no discernible separate risk factor associated with high or low BE/ME characteristic firms, and there is not a return premium associated with them. Their results suggest that high BE/ME stocks covary strongly with one another, not because they share a particular kind of risk, but because high BE/ME firms tend to have similar properties, being equally strong before firms eventually become distressed. They investigated portfolios with similar characteristics but different beta-loadings on the Fama and French (1993) factors to determine if covariance or characteristics determine expected returns. The results show that after controlling for firm characteristics, expected returns do not appear to be positively correlated to the beta-loadings on the Mkt, SMB, or HML factors.

a. The Null and Alternatives Models

In order to demonstrate their hypothesis, Daniel and Titman propose a null and two alternative models. The null hypothesis, model 1, is similar to the models proposed by Fama and French (1993) or Carhart (1997) among others, where a distress factor exists. Formally:

$$r_{i,t} = E[r_{i,t}] + \sum_j \beta_{ij} f_{j,t} + \theta_{i,t-1} f_{D,t} + \varepsilon_{i,t} \quad (1)$$

where $\varepsilon_{i,t} \rightarrow \eta(0, \sigma_{\varepsilon_i}^2)$ $f_{j,t} \rightarrow \eta(0, 1)$

β_{ij} is the beta-loading of firm i on factor j and $f_{j,t}$ is the return on factor j at time t . In this model $\theta_{i,t}$ is the beta-loading on the distress factor, and $f_{D,t}$ the return on the distress factor at time t . In this factor pricing model, expected returns are linear functions of all factor beta-loadings:

$$E_{t-1}[r_{i,t}] = r_{f,t} + \sum_j \beta_{ij} \lambda_j + \theta_{i,t-1} \lambda_D \quad (2)$$

In equation (2) the BE/ME ratio proxies for θ , and λ is the premium associated with the factors. Note that $\theta_{i,t}$ varies over time as firms move in and out of distress. If there are no firms that continually load in these factors, a purely statistical factor analysis will fail to detect whether the premium of the high BE/ME portfolio could be explained by the beta-loadings on these factors.

The first alternative, model 2, is one with time varying factor risk premium:

$$r_{i,t} = E[r_{i,t}] + \sum_j \beta_{ij} f_{j,t} + \varepsilon_{i,t} \quad (3)$$

where $\varepsilon_{i,t} \rightarrow \eta(0, \sigma_{\varepsilon_i}^2)$ $f_{j,t} \rightarrow \eta(0, 1)$

In this model, the variance-covariance matrix is time-invariant and there is no separated time-variant distress factor:

$$E [r_{i,t}] = r_{f,t} + \sum_j \beta_{ij} \lambda_{j,t-1} \quad (4)$$

but the risk premium on the factors varies through time.

As a second alternative, model 3, they propose their characteristic-based pricing model where the main assumption is that high BE/ME stocks realize a return premium that is unrelated to the underlying covariance structure:

$$r_{i,t} = E[r_{i,t}] + \sum_j \beta_{ij} f_{j,t} + \varepsilon_{i,t} \quad (5)$$

where $\varepsilon_{i,t} \rightarrow \eta(0, \sigma_{\varepsilon_i}^2)$ $f_{j,t} \rightarrow \eta(0, 1)$

Covariancies are stationary over time and can be described by a factor structure.

$$E [r_{i,t}] = a + b_1 \theta_{i,t-1} \quad (6)$$

However, factor beta-loadings do not describe expected returns. Daniel and Titman assumed expected returns are a function of the observable, slowly varying firm attribute $\theta_{i,t}$. They present empirical evidence that is inconsistent with all but the characteristic based model.

b. Empirical Evidence

Fama and French (1993) found that the stocks in the high BE/ME portfolio strongly covary with one another and have high returns. Their conclusion is that these stocks load in a factor that has a high premium. This intuition is consistent with the two first models. Daniel and Titman (1997) argue that if a factor has negative realizations, all the firms that load in that factor will be, on average, distressed. This is the reason why distress firms covary with one another, and it appears that all distressed firms load in a distress factor. In order to discriminate between model 1 and 3 it is necessary to see whether the return standard deviation of a portfolio increases if they all become distressed simultaneously. An increase is consistent with model 1. Model 3 also indicates that all firms with a distress characteristic will earn high returns and the returns are independent of whether or not there is a distress load factor. To analyze this question Daniel and Titman made a five year “backward looking” and “forward looking” study of the size and BE/ME based portfolios comparing the standard deviation of the monthly excess return. Their findings suggest that the high standard deviation did not disappear as predicted by model one.

If the factor model is correct, then a high (low) BE/ME stock with a low (high) beta-loading in the distress factor (BE/ME factor) should have a low (high) average return. The characteristic model predicts that a high (low) BE/ME should have a high (low) average return independent of its beta-loadings. In order to perform this test, Daniel and Titman (1997) formed portfolios based on characteristics (size and BE/ME), and then sorted these into subportfolios based on the firm’s preformation

factor beta-loadings. The results were portfolios with very similar size and BE/ME stocks but different beta-loadings on the BE/ME factor HML. These portfolios allowed examination as to whether characteristics or factor beta-loadings generated the average returns. They found a small difference (0.07 percent per month) between the portfolios with high and low beta-loadings on the BE/ME factor HML. The explanation for the results is likely due to the fact that when they sorted on the HML factor beta-loading, they picked up variation in the BE/ME ratio within relatively broad categories.

Daniel and Titman results open alternative lines of explanation to the missing risk factor of Fama and French (1993). The Daniel, Hirshleifer, and Subrahmanyam (1998) paper proposes a theory of stock market under/over reactions based on the psychological biases of investor overconfidence and biased self-attribution. In the next years more varied and complex pricing models will appear helping to achieve better knowledge of stock market behavior.

V. THE EXCHANGE RATE RISK

Up to this point an ICAPM or APT framework analyzes the possibility that stocks are multidimensionally priced. This dissertation is designed to analyze the Mexican stock market. If the market is not completely segmented and a large percentage of its investors are foreign, it is important to analyze or determine what role the exchange rate may possess as a potential source of risk. This section briefly reviews the exchange rate literature and current empirical research.

International investment is rapidly growing throughout the world. U.S. investors are attracted to foreign markets due to the possibilities of better performance and risk diversification. Solnik and Noetzlin (1982) results suggest that spreading investments over major foreign markets reduces risk while enhancing returns. Thus, a passive diversification along the lines of the Morgan Stanley Capital International World Stock Index has less risk than a purely domestic U.S. portfolio and provides a higher expected return, even though U.S. stocks make up more than half of this index. Papers defending the benefits of international asset allocation are Grauer and Hakansson (1987), Levy and Lerman (1988), or Jorion (1989) among others.

However, international investment implies various problems. Investors encounter cultural shock, different structures of financial institutions, lack of sources of information, and different trading rules, to name just a few. In addition, transaction costs, discriminatory taxation, and political risk must be considered. Prices of foreign assets and their distributions must be converted into domestic prices distributions using exchange rates, and exchange rate fluctuations add another dimension of risk and uncertainty in international capital markets. Not only returns in domestic currency are affected by exchange rate fluctuation, but foreign returns are impacted by exchange rate adjustments. Asset prices, interest rates, and foreign exchange rates are interrelated in a complex manner. Following Solnik (1991) a synthesis of the main variables that affect the exchange rate and its interrelations are presented in the rest of this section.

a. International Parity Relations

Fluctuation in exchange rates can be generated by a variety of sources and economic events. Basically, the theoretical parity relations of international finance are: purchasing power parity, international Fischer parity, foreign exchange expectation parity, and interest rate parity.

Purchasing power parity (PPP) states that exchange rates adjust perfectly to inflation differentials and in accordance with this theory the exchange rate at any moment should be:

$$S_t = S_{t-1} \frac{(1 + I_F)}{(1 + I_D)} \quad (7)$$

where S is the spot exchange rate in number of foreign currency units per domestic units, I_F is foreign inflation, and I_D is domestic inflation. When the PPP holds, the real return on an asset is identical for investors from any country. Exchange rate fluctuations have no influence on an international asset pricing theory since the rates only mirror inflation differentials and equalize real returns across countries. The international Fisher relation proposes that differences in nominal interest rates are caused by different inflationary expectations and real returns, formally:

$$\frac{(1 + r_D)}{(1 + r_F)} = \frac{(1 + rr_D)(1 + E[I_D])}{(1 + rr_F)(1 + E[I_F])} \quad (8)$$

where r is the nominal interest rate and r_r the real interest rate.

This international Fisher relation is an important international portfolio tool for managers because if real interest rates are stable, the interest rate differential is caused by different expectations of national inflation rates. The difference between two countries in real interest rates should be in equilibrium with the country risk. Otherwise, international investors would arbitrage the difference.

Foreign exchange expectation relation states that the forward exchange rate quoted at time zero for delivery at time t is equal to the expected value of the spot exchange rate at time t . This parity relation depends strongly on the certainty assumptions. It is claimed that the forward exchange rate should be an unbiased predictor of the future spot exchange rate, but other researchers claim the existence of a risk premium. If the foreign exchange expectation relationship holds, there is no reward for bearing foreign exchange uncertainty.

Interest rate parity states that in free money markets, the interest rate differential must equal the forward discount or premium, mathematically:

$$\frac{F_{0,t}}{S_0} = \frac{(1+r_F)}{(1+r_D)} \quad (9)$$

The four parity relationships should be combined in several ways linking the four variables: the interest rate differential, the inflation differential, the forward discount premium, and the exchange rate fluctuation. They indicate that interest rate

differentials reflect expectations about currency fluctuation and exchange risk is reduced to inflation uncertainty. This means that an investor interested in real returns would not be influenced by exchange rate uncertainty. The parity relationships described are a useful framework to analyze international monetary variables, but rely on restrictive assumptions about the perfection of trade in money and capital markets. In actuality, future inflation and exchange rates are uncertain, goods cannot be transferred immediately without cost, and there are import/export regulations, discriminatory taxes, and possible restrictive laws for international investors that result in frictions.

Adler and Dumas (1983) suggest that deviations from parity of individual commodities are a phenomenon in which existing microeconomics research is scarce and inconsistent. Segmentation of the goods market can induce segmentation of capital markets. Foreign exchange market reaction to PPP deviations can be analyzed only when physical events which are being anticipated by the market are made explicit. On the empirical side, tests and measures of the degree and specific sources of segmentation of the international capital markets are becoming essential.

b. Stock, Bonds and Exchange Rate

The major question is if exchange rate fluctuations affect domestic equity prices, and if so, in what way. International investors who use domestic currency to value a portfolio measure total return as the sum of returns on the assets in local currencies, plus any exchange rate fluctuation. The investors accept market and

exchange rate risk and the exchange rate fluctuation should be a matter of prime concern for international investors. A primary question is whether stocks and bonds provide a hedge against exchange rate fluctuation. If PPP holds, exchange rate fluctuation simply mirrors relative inflation and international investors do not hold any exchange risk. However, many studies indicate that in the short term the PPP does not hold. This means that real exchange rate fluctuation is a relevant variable to study.

Various economic theories have been proposed to explain the influence of real exchange rate fluctuations on domestic economies. Dornbusch (1980) explains that a decline in a currency's real exchange rate tends to improve competitiveness, which creates additional domestic inflation, reduces real income, domestic demand and production. The initial reduction of GNP should be offset by an improvement in international competitiveness and export demand until PPP is restored. The stock market should immediately discount the overall influence on the economy of an exchange rate fluctuation and could be positively or negatively affected depending on whether the short or long-term effect dominates. Lucas (1982) proposes a model where real growth in the domestic market leads to increased demand for the domestic currency. This increase in currency demand causes a rise in the relative value of the domestic currency. Because domestic stock prices are strongly influenced by real growth, the model justifies a positive association between real stock returns and domestic currency appreciation.

In the case of bond prices, which are directly linked to long-term interest rates, prices are explained by the relationship between changes in long-term interest rates and exchange rates. However, Cholerton, Pieraerts, and Solnik (1986), in a study applied to different countries, found both positive and negative correlation between bond prices and exchange rate fluctuations. This could be explained by different monetary policies adopted by different governments. In conclusion, theoretically the relationship between exchange rate fluctuations and stock and bond returns is not clear at this moment.

c. International Asset Pricing

A main concern for international investors is what determines asset prices. One main point in this issue is the efficiency of international capital markets. Could active asset allocation among countries consistently outperform the world market index? There is less competition among countries than within a single market and at this point, there is little empirical evidence exploring international efficiency. This issue is analyzed in terms of integration or segmentation. An integrated world financial market would achieve international efficiency, in the sense that arbitrage across markets would not exist. On the other hand, international markets could be segmented. Although each national market could be efficient, numerous factors might prevent international flows from taking advantage of arbitrage opportunities. The main factors on frictions could be: psychological barriers, legal restrictions, transaction costs, discriminatory transactions, political risk and exchange risk. All

these factors tend to reduce international capital flows and lead to partial or completely segmented markets. However, the flow of foreign investment has been rapidly growing through the years and it seems that the international markets are not fully segmented. The degree of international market efficiency is an empirical question that has not yet been answered. Solnik (1974a) is pioneer in international asset pricing models. He proposes an equilibrium model of the international capital market with the hypothesis that security price behavior is consistent with a single world market concept. He suggests that investors will be indifferent between choosing portfolios from three funds: a portfolio of the world stock market, a portfolio of international bonds, and a risk free portfolio of their own country. However, he assumes perfect capital markets, and no constraints on international flows. Similarly, the Stulz (1981) model allows differences in consumption opportunity sets across countries. He suggests that real expected excess returns on a risky asset are proportional to the covariance of the return of that asset with changes in the world real consumption rate. His model also has no barriers to international investment.

In contrast, several authors have developed international equilibrium asset pricing models taking into account different imperfections. Among them are: Black (1974), Errunza and Losq (1985a, 1989), Stapleton and Subrahmanyam (1977), and Eun and Janakiramanan (1986). All the models are complex and so far consensus has not been reached. The risk premium has a more complex function than in the traditional CAPM and depends on the form of market imperfections, relative wealth

of the country investors, the consumption opportunity set, and the parameters of their utility function.

d. Empirical Research

Jorion (1991) states that until his study, no one had addressed the problem of empirically measuring whether currency exposure commands a risk premium in the stock market. He performed his test on samples of industry portfolios. He found different exposures to the exchange rate fluctuation within different industries. First he runs a model with two factors: a U.S. market index and an orthogonal component of innovations in a trade-weighted exchange rate. The orthogonalization is essential to avoid spurious pricing of the exchange rate factor because of a possible correlation with a priced market. Jorion also uses the six economic factors postulated by Chen, Roll, and Ross (1986) and the orthogonal component of the exchange rate as a seventh factor. In both models the exchange rate premium is statistically insignificant.

In contrast Dumas and Solnik (1995) work with four countries, Germany, the United Kingdom, Japan, and the United States. They use returns in dollars and the U.S. T-bill as a reference for excess returns portfolios for the 1970-1991 period. They conclude that foreign-exchange risk premium is a significant component of securities rates of return in the international financial market and that the international APT dominates the classic APT. They suggest that the foreign exchange rate factor is necessary to explain rates of return on currencies. To check the robustness of their

results they include a bond factor. The reason for the inclusion of the bond factor is that the significance of foreign exchange risk premium in the international APT could be an artifact linked to the large outstanding amount of government bonds which have nominal denominations in dollars. These bonds are in investors' portfolios and should, perhaps, have been included in the market portfolio. It is at least conceivable that the foreign-exchange risk premium is a proxy for a missing bond factor. However, their results suggest that the foreign exchange risk premium cannot be interpreted as a proxy for missing bonds in the market portfolio. Other authors that include the bond factor with the exchange factor are Oexelheim and Wihlborg (1987) and Prasad and Rajan (1995).

Early studies (Solnik, 1974b; Stehle, 1977; and Jorion and Schwartz, 1986) shed light on issues of market segmentation between pairs of nations, but they are inconclusive about international market segmentation and neglect the role of exchange risk. Choi and Rajan (1997) made a joint test of market segmentation and exchange risk premium in Canada, France, Germany, Italy, Japan, Switzerland, and the U.K. for the period of January 1981 to December 1989. They perform a joint test of the segmentation of the world capital markets and the presence of the exchange risk factor along with a multifactor asset return model. In contrast to former papers, they used individual stock price data and jointly consider the role of market segmentation and exchange rate risk. Their findings suggest that: the factor structure of asset returns is generally heterogeneous internationally; many national capital markets can be described as partially segmented or partially integrated rather than the

polar case of complete segmentation or integration; and exchange risk is a significant factor affecting asset returns in addition to the domestic and world market factors in select international capital markets.

Hamao (1988) and Brown and Otsuki (1990) examine the Japanese stock market and find that the exchange risk is not priced. Contrasting, Choi, Hikari, and Takezawa (1998) find that exchange rate fluctuations are generally priced in Japan. Using an unconditional model, they prove that the yen/dollar exchange is priced. In addition, they include the bond interest factor and a conditional model to improve the robustness of their experiment. The exchange factor remains significant with all these variants.

e. Summary

There is no clear consensus in the existing published literature about exchange risk. Results depend on the country and the period, since exchange rate fluctuations are sensitive to numerous market frictions and monetary policies. However, recent work of Dumas and Solnik (1995), Choi and Rajan (1997), and Choi, Hikari, and Takewaza (1998) have found that exchange rate risk is priced in several countries using different approaches. It appears that stocks do not correct real exchange rate fluctuations and are therefore a bad monetary hedge. It seems that real exchange rate fluctuations are unpredictable and not short-term adjusted and foreign investors are subject to foreign exchange as well as domestic risks.

VI. CONCLUSION

Asset pricing theory begun in 1964 with Sharpe's CAPM. Several anomalies related to the CAPM were detected in the following years. The size, P/E, BE/ME, leverage, and momentum are the most relevant. So far, asset pricing theory is a topic where no consensus has been reached. Several authors propose that these anomalies are due to risk when priced in a multidimensional framework. The ICAPM of Merton (1973), the APT of Ross (1976), and the empirical work of Fama and French (1992, 1993, and 1996) are on this line. Some researchers still defend the CAPM by explaining the anomalies as bias, sample, period used, methodology problems, or conditional versions with time varying betas or time varying premium. There is another line of authors that propose that the market has not been efficient and offered a lot of virtual arbitrage opportunities due to investors' overreactions, fads and irrational behaviors (See Haugen, 1994; De Bond and Thaler, 1995; and Lakonishok, Shleifer and Vishny, 1994).

Along a different line of research, the characteristic-based pricing model does not depend on the covariances matrix, which is the foundation of all the multifactor versions. Daniel and Titman (1997) suggest that the characteristic matters and not the factor beta-loading. A stock earns the "stock" premium even if its return pattern is similar to a bond. This demonstrates that there is no evidence of a separate distress factor and that stocks with similar factor sensitivities tend to become distressed at the same time. It appears that characteristics and not factor beta-loadings determine expected returns. The fact that characteristics predict expected returns better than risk

is striking for portfolio analysis, performance evaluation, and corporate finance.

Daniel and Titman explain that the reason for their findings could be that investors consistently believed that size and BE/ME ratio were proxies for systematic risk and as a result they demanded higher discount rates on stocks with these characteristics.

If this is the case, the patterns observed (1973-1993) will not be repeated in the future.

The goal of this paper is to form a pricing model to describe the Mexican stock market in the 1989-1998 period. If international capital markets are completely integrated and peso/dollar exchange rate perfectly correlate with the inflation differential (PPP is always the same in both countries) international financing and investment decisions are essentially the same as domestic ones. Mexico suffered a strong devaluation shock in December 1994 and there are signs of under/over valuation of the peso vs. dollar during this period. The peso/dollar exchange rate is a product of a flexible exchange rate system that suffers short term economic shocks (government controls, restrictions on international capital flows, political risk, transaction costs, information costs, accounting imperfections, and differences in culture and practices of business institutions) that deviate the spot exchange from a fundamental value that equalizes PPP between both countries. The recent empirical evidence mentioned in this chapter suggests that it is important to consider the exchange rate fluctuation as a source of risk independently of the variant of the pricing model used.

CHAPTER 3

CHARACTERISTICS AND EMPIRICAL RESEARCH OF THE MEXICAN STOCK MARKET

I. INTRODUCTION

The goal of this paper is to explain the return behavior of Mexican stock market. The objective is not to analyze the overall importance of the Mexican stock market in the development of the country. Social contribution, regulatory aspects of the stock market, and other additional factors are not addressed or evaluated.

To the reader interested in these topics, the following authors are recommended; for a detailed history of the Mexican stock exchange see Caso (1971, 1986), Aspe (1981), Ortiz (1993a). For a structural analysis see Castaings (1984), and Ejea (1987). For economic development and the emerging capital markets, see Ortiz (1993b), and Errunza (1992). Globalization and NAFTA's influence on the stock market is explored in Ortiz (1993c), and Cabello and Ortiz (1993); inflation and fiscal effects in the securities markets are explored by Gil (1981) and Gonzalez (1982), and a complete description of the Mexican financial system is in Blanco and Verma (1996).

The Arturo Alonso Cassini Library, the library of the Mexican Stock Exchange, contains more than a thousand titles in the fields of economics, finance and securities markets. It also contains a collection of all the works published by the Mexican

Securities Market “Bolsa Mexicana de Valores” (BMV), since 1968. Unfortunately electronic data is only available (depending on the specific information) for shorter periods.

Section II provides a framework of the history, trading systems, market indices, and availability of information. The linkage of the securities market, with the Mexican financial system, the limited statistics of the market and regulations are briefly detailed.

Section III describes the research conducted on Mexico and the international research that compares Mexico with other countries.

II. THE MEXICAN SECURITIES MARKET

The BMV is a private institution that operates under a concession from the Minister of Finance and Public Credit (Secretaría de Hacienda y Crédito Público, or SHCP) and is governed by the Securities Market Act. Shareholders consist exclusively of authorized brokerage firms, each of which owns a single share. As of December 1998, there were 33 share-holders. Among them are Merrill Lynch Mexico, Goldman Sachs Mexico, Bankers Trust, and the two huge Mexican financial groups, Bancomer and Banamex.

The main purpose of the exchange is to provide the infrastructure and necessary service to effectively process the offering, issuing, and trading of securities.

Functions of the BMV are: to provide the physical, administrative and technological infrastructure necessary for the securities market to function properly; and to publish

securities information including information from the trading floor, electronic trading, and any relevant event along with financial information on listed companies.

Administratively, the BMV is responsible for processing securities transactions and transmitting the information to the central securities depository. The BMV is also responsible for overseeing the activities of issuing companies and brokerage firms and insuring compliance with the bylaws and professional code of ethics of the exchange. Lastly, the BMV is to encourage the expansion and competitiveness of the Mexican securities market.

The most relevant of these functions for financial researchers is concerned with information processing. Unfortunately, this is one of the weakest points in the Mexican exchange. Hakim (1992) argues that this is the main cause of the scarcity of financial literature on the Mexican market. For instance, the electronic access to stock prices are only available from 1992, foreign investor holdings from 1994, and mutual fund holdings from 1997. With respect to the goal of encouraging the expansion and competitiveness of the Mexican security market, some actions that have been taken on this line are mentioned below, but in fact, in December of 1998, the market capitalization in dollars is less than half of that of December 1993. Therefore, it is not clear whether the Mexican exchange is achieving the goal of expansion and competitiveness.

BMV is the headquarters of the organized securities market in Mexico. As such, it does not participate directly in trading or in setting prices but coordinates and regulates the process. Transactions are carried out through the electronic trading,

transaction, registry, and allocation system for equities (SENTRA-CAPITALES).

Two business days after a transaction is completed, Mexico's central securities depository (S.D. Indeval) transfers the securities from the selling broker to the buying brokers' firm account.

Throughout its development, the BMV has played a key role in Mexico's economic development by channeling savings to productive investments. In this decade, more than 32 billion dollars (Annual Statistics Report, BMV, 1997) in private sector financing has been issued through the BMV. As of June 1999, 168 stocks are listed with a market capitalization of over 137 billion dollars and the value of stock trading surpassed 34 billion dollars in 1998 (Facts and Figures, BMV, 1998).

However, in proportion, the overall importance of the stock market channeling savings to the firms is less than in developed countries such as the U.S., Japan, and Germany.

a. History

In 1867, due to the great mining boom, authorities issued the securities brokerage regulatory law. However, the first organized security market in the country, the "Bolsa Nacional de México," did not appear until 1894. Between the original and the current BMV, a succession of institutions have provided facilities for trading securities, but interruptions occurred due to the Mexican revolution and the First World War.

The present Mexican financial and securities system began to take shape with the first banking convention in 1924 and was formalized by the Credit Organization Law of 1932 and the Exchange Regulation Law in 1933. This legal framework remained practically intact until the government of President Luis Echeverria in the 1970s. The Securities Market Act went into effect in 1975 and it opened broad new possibilities of expansion for the securities market. The “Bolsa de Valores de México” changed its name to “Bolsa Mexicana de Valores” and consolidated activities that were previously scattered among several exchange institutions (Mexico, Guadalajara and Monterrey) that joined the new institution. In 1978, the government created the National Securities Depository (S.D. Indeval) and in 1980 The Mexican Securities Industry Association (AMIB). In 1990, authorities re-instituted what is called the “mixed regime” (from 1982 to 1990 Mexican banks were state-owned) paving the way for the re-privatization of Mexico’s banks and the formation of financial groups under the Financial Group Law. The most recent amendments to the Securities Markets Act provides for an orderly internationalization of national securities activity, deregulation of trading in order for the market to begin self-regulation, simplification of administrative procedures, and the formation of non-bank financial groups. In November 1996, BMV chairman Manuel Robleda was appointed President of the International Federation of Stock Exchanges (FIBV) and for the first time all securities listed on the exchange were traded through the electronic system BVM-SENTRA Capitales.

In January 1997, the CNBV issued rules for the creation of an options and futures market in Mexico and S.D. Indeval implemented the securities lending program. Later, in April 1997, trading of debt instruments issued abroad by the Mexican Federal Government began on July 15, 1997, and The International Quotation System (SIC) began operations by listing stock from four Argentinean issuers.

b. Trading System

The conventional trading system traditionally refers to the activities that take place on the trading floor where floor brokers trade capital market securities, but in Mexico it has disappeared. Since 1999, all the stocks are traded only through the electronic trading system BMV-SENTRA Capiales which went on line in 1996 (during 1996 and 1997 floor brokers and the SENTRA system worked in parallel). This change increased the efficiency and eased the globalization of the Mexican market.

c. Stock Market Index

Currently, the BVM calculates and publishes several indices. The Price Quotations Index (IPC) is the leading indicator of the performance of the stock market as a whole. It expresses an index based on a value-weighted representative sample of stocks traded on the BMV. The sample is reviewed once every two months

and is composed of 34 issuers that participate in different sectors of the economy.

The current structure has been used since 1978. The calculation uses the equation:

$$I_t = I_{t-1} \frac{\sum_{i=1}^N P_{it} Q_{it}}{\sum_{i=1}^N P_{i,t-1} Q_{i,t-1} F_{it}} \quad (1)$$

Where:

I_t = IPC on day t

P_{it} = Price of issuer on day t

Q_{it} = Shares of issuer i listed on the BMV on day t

F_{it} = Adjustment factor for rights on stock i on day t

$t-1$ = Preceding business day

$i = 1, 2, 3, \dots, N$

N = Number of issuers in the sample

The P_{it} , used in determining the value of the Index from 14:50 to 15:00 hrs., is equivalent to the volume average of the P_{it} from ten minutes earlier. This variable is calculated every time a trade is recorded. The purpose is to determine a representative price of the last ten minutes of trading for calculating the closing value of the index. The equation indicates that the sum of the market capitalization of that sample on the business day, adjusted (if applicable), determines the change in the IPC.

Any change in the number of securities listed modifies the structure of the index because price and/or market capitalization is used as a weighting factor. This is why the value of issuers that declare dividends must be adjusted by applying an adjustment factor to the previous day's market capitalization. If no adjustment is required, the factor is equal to one. Many investors complain that the IPC is not a good market proxy because Telmex dominates the weight on it, but it should be considered a good proxy because its correlation with a value-weighted index that includes all the traded stocks in the 1989-1998 period is 0.97 and with an equal-weighted market index the correlation is 0.85.

Besides the IPC, the BMV publishes sector indices which measure performance in certain areas or sectors of economic activity. The method used is the same as for the IPC, with the only difference being the size of the sample and the number of shares in each economic sector. The Mexico Index (INMEX) is used as an underlying value, which means that it serves as a base value for some derivative issues. The sample used to calculate this index includes the most representative and highest-marketable series of between 20 and 25 issuers. The weight of each issuer may not exceed 10 percent of the total and the sample is revised every six months. BMV also publishes a Medium Sized Company Index (IP-MMEX) which is designed to reflect the performance of medium-sized companies. As of October 1997, the sample consisted of stocks from 18 issuers. The IP-MMEX sample is reviewed every two months and the equation is the same as the IPC's. Currently, there is the possibility or threat of the loss of medium-sized companies due to low trading

volume. This probable disappearance could affect the overall development of the market by increasing the concentration of the market among a few big firms.

d. Information Available

One of the main functions of the BMV is to provide precise, complete, and timely information about transactions and relevant events that affect the securities market. Junco and Sanchez (1990) reported that serious information-related frictions exist in the Mexican security market inducing under-pricing anomalies. Pursuing improvements in this area, the BMV has an Information Center that provides computer lookup services and publications. Daily publications include a Provisional Bulletin, a Capital Market Bulletin, and a Money and Metals Market Bulletin. Facts and Figures which shows the performance of market indicators, yields, trades, new offerings, highest-yield instruments, and major financial indicators for companies listed on the BMV is published monthly. Financial statements of all issuers are published quarterly and the Annual Statistics Report and Financial Facts and Figures are published annually.

The BMV offers specialists that need to closely monitor market activities an Automated Integral Securities System (SIVA) and the Electronic Securities Bulletin (BBE). SIVA transmits real-time information regarding trading floor activity and bids and trades recorded in the electronic trading systems. It also provides financial information on issuers. The system is designed for traders, analysts, company treasurers, and investors and BBE enables users to access information at the close of

trading. It provides information equivalent to that published by the BMV in its bulletin published the following day. However, in personal interviews, some brokers complain about the delayed and inaccurate information that is released by some firms.

e. BMV Links with the Mexican Financial System

BMV is considered a regulatory institution and must be vigilant about the integrity of the market and promote strict self-regulatory standards. Other regulatory institutions of the Mexican securities market are: SHCP, National Banking and Securities Commission (CNBV), and the Central Bank (Banco de México).

The SHCP is the highest federal government authority on economic matters as well as the executive arm of financial policy. Among its functions are to grant and revoke concessions for financial intermediaries and the stock exchange. It is empowered to levy administrative sanctions for violations of laws and regulations.

The CNBV is an agency of the SHCP. It is autonomous and has executive powers to regulate securities market operations, the performance of securities intermediaries, and the central securities depository. It is also responsible for maintaining the National Registry of Securities and Intermediaries (NRSI) which lists all the securities intermediaries and all the securities traded in the BMV.

The Mexican Central Bank is an autonomous financial institution that is responsible for supplying currency, offering government debt instruments, controlling inflation, and contributing to the stability of the Mexican peso against foreign currencies.

In addition to the regulatory institutions, it is important to mention the participation of support organizations such as the Mexican Securities Industry Association (AMIB), the Securities Market Support Fund, the National Securities Depository (S.D. Indeval), and the Mexican Academy of Securities Law. The AMIB represents Mexican brokerage firms, particularly before the regulatory authorities. Its purpose is to promote a healthy development of intermediary activities and the adoption of self-regulatory measures while supporting the interests of its members and the securities market in general. The Securities Market Support Fund helps securities intermediaries meet their obligations and is formed by contributions from all of the brokerage firms listed in the NRSI. The S.D. Indeval maintains custody of all of the securities that are traded on the BMV and is in charge of administering, clearing, settling, and transferring securities so there is no need to physically transfer traded shares. The Mexican Academy of Securities Law contributes to the modernization of securities market regulations. It is continually working on updating securities law and keeping the securities and financial communities abreast of current legislation. It also conducts research in the standards that regulate market operations in order to improve the standards.

f. Regulations

It is important to be aware of the most important laws and regulations that govern the securities market: the Securities Market Act, the Mutual Funds Act, the by-laws of the BMV, and the Code of Ethics for the Mexican Securities Community.

The Securities Market Act regulates securities public offerings, intermediaries in the market, and the activities of individuals, corporations, and operating bodies that participate in securities exchange. The Act consists of 117 articles, grouped into ten chapters: I Preliminary provisions, II The National Registry of Securities and Intermediaries, III Brokerage firms and securities specialists, IV Securities exchanges, V The National Securities Commission, VI Securities depositories, VII Procedures for protecting the interests of investors, VIII Securities Contacts, IX International transactions, X Automation.

The Mutual Funds Act defines the organization and functioning of each of the different types of mutual funds (common, debt, and venture capital), the fund managers, and the trading of shares on the securities market. It defines the role of the authorities responsible for promoting development and enforcing the compliance and adherence to regulations.

The by-laws of the BMV establish operating standards for the admission, suspension, and expulsion of BMV members, securities listing and maintenance requirements, securities suspension and cancellation, general trading rules, and publication of information.

The Code of Ethics for the Mexican Securities Community answers to the need for integrity in the market, ensuring that it is open and accessible and that it operates in keeping with the standards of other world stock exchanges. The Code establishes standards of conduct for brokerage firms and their personnel, along with standards for board members, directors, representatives, and employees of securities market

support institutions. These norms promote fair and sound market practices in order to discourage price manipulation and insider trading and to create a climate of trustworthiness and reliability. However, the Haugen, Ortiz, and Arjona (1985) event study reveals a strong anticipated reaction in earnings announcements (more details of this paper are presented in the next section). This is consistent with price manipulation and insider trading. Unfortunately, there are no recent studies available on this topic.

In addition to the mentioned regulations, trading on the BMV is also governed by supplementary provisions contained in the following laws: The Financial Groups Law, the Credit Institutions Law, the Foreign Investment Law, the Debt Securities and Transactions Law, the General Law on Mercantile Companies, the Mercantile and Civil Procedures Law, and the Commerce Code. These laws are the legal and regulatory framework of the securities market in Mexico and are available to the public at the BMV Information Center.

g. Size of the Market

Table 1 contains some indicators of the size and development of the market in the years indicated, as well as some statistics showing the importance of foreign participation in the BMV. It is important to note the constant growth that the market had during the 1991-1993 period and the decline suffered in 1994 and 1995.

TABLE 1
Measure of Size and Performance of the BMV

This table presents annual information from the BMV such as the main index IPC, the net financing, average daily traded value, foreign investment and foreign investment vs. market capitalization value.

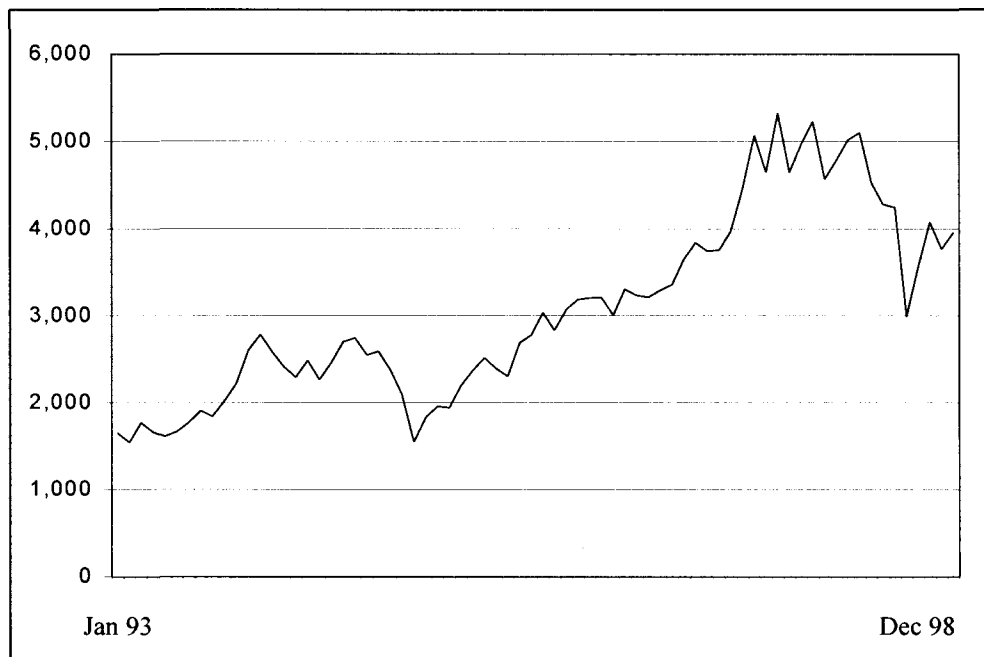
Concept	1991	1992	1993	1994	1995	1996	1997	1998
IPC (percent change in US \$)	118.7	20.9	48.6	-15.0	-24.4	18.4	51.2	-37.9
Net Financing through BMV (billion US\$)	3.2	5.1	11.3	3.8	1.1	1.9	2.5	1.2
Average Daily Traded Value in Stocks (million US\$)	127	178	248	336	137	145	195	127
Foreign Investment (billion US\$)	24	43	76	55	28	34	52	33
Foreign Investment Vs, Market Capitalization Value (percent)	18	21	27	26	27	29	31	35

Source: BMW, Annual Facts and Figures 1998.

It is interesting to observe that although foreign investment diminished from 78 billion dollars in 1993 to 26 billion in 1995, its share of the market remained constant. Figure 1 shows the IPC performance during the last five years. Figure 2 presents the market capitalization value in billions of dollars (U.S.) from the same period.

The information presented in this chapter is to provide the reader with an idea of the size of the Mexican securities market along with its development, structure, regulatory control, and linkage with the Mexican financial system.

FIGURE 1
The IPC Performance (January 1993 –December 1998)



Source BMV, Annual Facts and Figures from 1993, 1994, 1995, 1996, 1997, 1998.

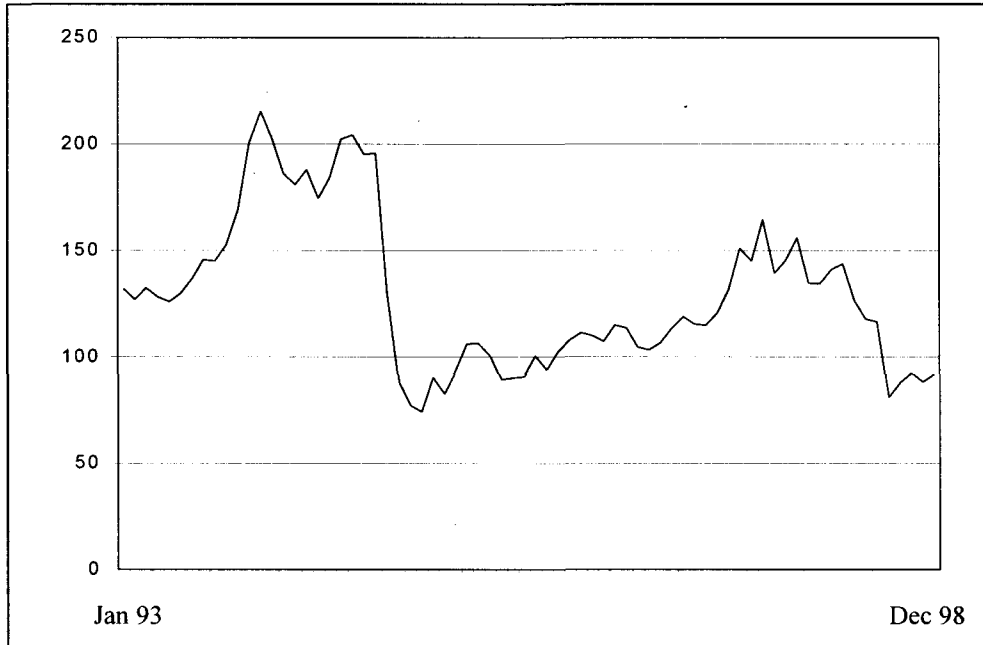
h. Conclusion

The Mexican market is just emerging. During the years 1986-1987 the market experienced growth, but fell in 1988. Six years later, in 1993 and the beginning of 1994, the market reached a historical peak in trading volume and capitalization, but Mexico's economic problems of 1994-1995 were reflected in market contraction.

The main problems pointed out by academicians have been the availability of readable data bases, information-related frictions, size of the market, and low trading volume. Unfortunately, these are not deeply documented, but in the next section

FIGURE 2

Market Capitalization From January 1993 to December 1998.



Billions of dollars (U.S.). Source BMV, Annual Facts and Figures from 1993, 1994, 1995, 1996, 1997, 1998.

some of the empirical research performed in the Mexican stock market is presented. In addition, the Mexican securities market is more volatile compared with developed countries. However, it is listed in the Financial Times Actuaries World Indices (FTAWI) published by the Financial Times in cooperation with Goldman Sachs & Co., and Wood Mackenzie & Co. and it stands out among emerging markets in developing countries. Due to the importance of the stock market in developed

countries, it is important to research stock market behavior and promote its development.

III. EMPIRICAL RESEARCH ON THE MEXICAN STOCK MARKET

Hakim (1992) argued that there is a lack of studies in financial literature caused by the absence of available computer readable databases. The problem is the most consistent factor causing the scarcity of literature and limiting empirical financial research in Mexico. In the University Microfilm International (UMI) digital library of dissertations and theses only three dissertations related to market efficiency, CAPM-related anomalies, pricing models, institutional investors, and mutual funds are listed under the subject "Mexico and Finance". Less than ten formal articles can be located in ABI/INFORM, Business and Company ASAP, and LEXIS NEXIS when searching for the same topic. Several journals are published in Mexico, but in general, the publications are directed toward practitioners or focused on regulatory or political economic problems. The BMV and the main banks and brokerage firms publish different bulletins containing statistics, recommendations and recent news relating to the stock market. Formal investigation of the stock market is scarce. This section does not pretend to describe all the research on the topic, but selectively reviews some of the formal and relevant empirical research that exists.

a. Mexico

Ortiz (1980) is one of the earliest empirical researchers of the market efficiency hypothesis applied to the Mexican market. He used the runs methodology with 79 registered stocks and 154 monthly time series observations. His results suggest that the efficient market hypothesis should be rejected and that smart investors can take advantage of inefficiencies in the Mexican stock market.

Junco and Sanchez (1990) tested the semi-strong form efficiency of the BMV over the period 1985-1990. They followed the Grossman and Stiglitz (1976) methodology and concluded that the Mexican market is not semi-strong form efficient. They suggested that the problem occurs because firms are not always prompt in releasing financial results and the information is not always accurate. Given these conditions, they concluded that security analysts and private investors are likely to under-price securities. They also suggested that the Mexican stock market is efficiently priced relative to macroeconomic information.

Herrera (1992) examined the Mexican stock market to determine whether the empirical anomalies related with seasonality and size present in the U.S. and other international markets are also present in Mexico. Herrera (1992) suggested that the institutional and regulatory environment in Mexico provides a unique setting in which market efficiency and the CAPM can be tested through the examination of market anomalies. Specifically, he examined the Mexican market for stock return seasonality and size anomaly. The database used to examine monthly seasonality in the Mexican market included daily and monthly values for the IPC for the period

January 1980 through August 1991. The database also contained monthly prices and quotations for indices established on clusters of economy activity. To test the size anomaly he used the daily and monthly returns of all stocks listed from January 1987 to August 1991.

Herrera performed autocorrelation parametric and non-parametric tests, controlling for heteroskedasticity and autocorrelation using the general least squares method. His results suggest that the random walk hypothesis should be rejected. He detected the presence of a systematic homogeneous cyclicality between consecutive months, which indicates seasonality in the Mexican market. He finds the presence of high return in January compared with the rest of the year. The high January returns are associated with a higher small firm premium and a higher dispersion of returns. He observes that the January seasonality is clearly not the result of tax-loss-selling or transaction costs alone and his results indicate that the effect seems to be associated with the release of information during the first two calendar months and only in specific industries. Mining, manufacturing, service, and miscellaneous industries reflect the effect, but construction and commerce do not.

The same study finds a difference of premium between small and large companies (3.4% per annum) present only in January. However, after controlling for risk (in a CAPM framework), the results indicate the empirical anomalies diminish to non-significant levels. January has a larger risk premium than other months, and it is the only month characterized by a consistently positive significant relationship

between expected return and risk. His results imply that systematic risk is reflected in price only in the month of January.

The evidence indicates that the efficiency of the Mexican Stock Market cannot be rejected on the basis of size and seasonality tests. He finds explanations based on asymmetric information more appealing. He hypothesizes that anomalies are the result of erratic behavior of a group of firms that are very small relative to the entire market. By eliminating the group of erratic small firms, the CAPM explains both seasonality and size.

Herrera argues that the January effect in Mexico is weaker than in the U.S. over the counter (OTC) markets and the size effect in Mexico is similar to the U.S. OTC markets. He explains that anomalies in Mexico can be adequately explained by the CAPM. His explanation does not concur with the results of Chen, Roll, and Ross (1986) which indicate that the CAPM does not explain the anomaly but that the APT does.

Herrera suggests that the Mexican market is dominated by a small number of depository institutions (banks) which are allowed to provide full-brokerage services and to engage in securities activities. This concentration in the market may reduce the intensity of information-related frictions and provide greater homogeneity of expectations. Also, the number of securities traded in Mexico is very small compared to the U.S. and the small number eases the problem of information dissemination.

Herrera's results are striking in two areas. First, the anomalies in a small emergent market are similar or weaker than in developed markets. Second, the

CAPM explains the anomalies and multifactor models do not add explanatory power to the CAPM model. This is inconsistent with Fama and French (1992,1993), Carhart (1997) and others. These findings can be explained as follows; as compared to the U.S., the small “naive” investors do not have access to the stock market in Mexico. Small investors must access the market through “smart” investors such as mutual funds. A few banks, brokerage firms, and mutual funds control trading and this small, concentrated, and smart market behavior follows the CAPM better than a huge market with a large percentage of naive investors.

Johnson (1992) studied whether the Mexican stock market is weak form efficient. The data included 24 of the largest firms in the Mexican market from 1987 to 1991. He worked with daily, weekly, and monthly data, and tested the normality distribution of returns. He found leptokurtosis in the sample half with the lowest liquidity. The sample was positively skewed and the Shapiro-Wilk test rejected the null hypothesis of normal distribution at a 0.05 percent significance level. He also tested serial correlation using Durbin-Watson, runs, and filters. His results suggest that serial correlation is present, but the magnitude of the correlation coefficients (0.2 being the largest) is not sufficient enough to be useful to investors. In conclusion, the weak form efficiency is rejected for 19 of 24 securities, but it is doubtful that profitable trading rules can be developed because of the magnitude of the correlation. He suggests that lack of trading volume and information frictions can explain the serial correlation found.

Hakim (1992) stated that there is a lack of research in Mexican financial literature due primarily to the absence of generally available computer readable databases. He argued that most of the information is scattered in pamphlets and bulletins. He used the database compiled by the Instituto Tecnológico Autónomo de México (ITAM) which contains information regarding adjusted prices of stocks listed on the BMV. The data contains weekly and monthly information for 91 stocks for the period 1972 to 1981 period. The prices are adjusted for cash dividends, stock dividends, subscriptions and splits.

Hakim (1992) searched for the number of stocks necessary to form a well-diversified portfolio. Using monthly data, he suggests that using a twenty stock portfolio can eliminate unsystematic risk. Repeating the experiment with weekly data, he found that only 16 stocks were necessary. He checked autocorrelation of weekly returns of 91 stocks from 1972 to 1981, finding that at lag of one, twenty-eight stocks had autocorrelation with 23 being negative. For 37 stocks he checked the monthly autocorrelation during the period 1972-1981, finding only seven stocks with first order serial correlation (four negative and three positive). He suggests that the results of this test on monthly real returns on individual stocks and portfolios seem to indicate weak-form inefficiency. Using a CAPM model, he tested serial correlation of abnormal returns, using 34 stocks over the period 1972-1981, finding 19 negative serial correlations at the first month lag. In monthly abnormal returns, at lag one, fifteen stocks were negatively significant.

His overall results suggest that the Mexican stock market was weak form inefficient during the period analyzed. However, all the significant profits were eliminated with the inclusion of minimum transaction costs. Using 15 different reverse filter rules, he finds only a very few cases in which filter rules on individual stocks beat a buy-and-hold strategy after transaction costs were considered. The same result holds for an equally-weighted portfolio. These results suggest that the negative serial correlation found in both returns and excess returns, although statistically significant, may not be of economic importance.

Hakim (1992) explained that the lack of trading volume in the secondary market for most of the stocks listed in the Mexican stock exchange seems to be one of the main problems that professional investors face, which suggests the problem could be reduced by the implementation of a trading specialist.

b. International Studies

Errunza (1983) studied fifteen emergent markets, one of which was Mexico. He worked with the 1976-1980 period and found that while these markets may be less efficient than markets in developed countries, the high transaction costs negate profitably trading rules. He pointed out that emergent markets have low correlation with developed markets and this is beneficial for international investors.

Errunza and Losq (1985b) worked with ten emerging markets, including Mexico, from 1975 to 1981. They found that returns follow a log-normal distribution similar to that exhibited for the 30 Dow Jones Industrial Average securities traded on

the NYSE. They also found that the average serial correlation was not significantly different from zero. Run tests further supported the hypothesis that stock returns are independently distributed. They conclude that emerging markets are not as efficient as the developed markets but that they closely parallel the small European markets.

Haugen, Ortiz, and Arjona (1985) compared the efficiency of the U.S. market versus the Mexican market. They researched the period from 1975 to 1980 using weekly and quarterly data of 40 firms in 1975 and increased to 75 by 1980. They compared the Mexican firms with 75 similar size U.S. companies from CRSP files and found that earnings announcements had a more significant effect on Mexican stocks than on U.S. stocks. The difference was thought to be the result of more available channels of information. They also found a large effect preliminary to earnings reports in the Mexican market. There appears to be a trend fifteen weeks before the announcements and a strong trend if the news is negative. This lead trend appears in the U.S. sample, but more weakly. They conclude that the U.S. market is comparatively more efficient than the Mexican market and opportunities may exist for excess profits.

Malkamaki, Martikainen, and Pertunen (1991) studied risk and stock price behavior of 24 world stock market indices, including Mexico. They compared two asset pricing models: the CAPM and the APT. In the first phase, they studied the sensitivity of each of the stock market indices to the movements of the worldwide market portfolio. The sensitivity is measured by determining the beta coefficient for each security market index and applying the CAPM. In the second phase, they found

which of the world stock markets fall into the same risk category using the APT by using a factor analysis technique. They used the Financial Times Actuaries World Indices published daily since March 1987. These indices are computed for 24 individual countries, ten regions of the world, and the world as a whole. The indices were expressed as dollars (U.S.) with a base value of 100 on December 31, 1986.

The world index daily mean return and standard deviation were 0.0007 and 0.0061 respectively. Mexico had a daily mean return of 0.0018 and this is 2.57 times the world index mean, and a standard deviation of 0.0235 which is 3.85 times larger than the world index. In both parameters, Mexico had the highest measure. In kurtosis, Mexico was in fourth place after the U.S., Switzerland, and Belgium. In skewness, Mexico was second after Belgium (with positive skewness).

Malkamaki et al. found in a CAPM framework that Mexico had a beta of 0.08, the lowest of the 24 countries, indicating a very low correlation with the rest of the world. In the APT framework they used a factor analysis approach to determine the global common factors that explain the returns of the world stock markets and also to estimate the systematic risk components of each individual stock market. They found that four-factors describe the cross-sectional variation. Most of the European stock exchanges are loaded to the first empirical factor. This indicates a strong positive empirical relationship between stock returns in these European countries. Japan is also loaded to this European factor. The second factor clearly represents the Oceanic factor consisting of Singapore, Malaysia, Hong Kong, Australia, and New Zealand. Also Japan has its second highest loading on this factor. The third factor can be seen

to represent the North America stock exchanges, since both the U.S. and Canada have their highest loadings in this factor. The United Kingdom and Netherlands are also situated in the third factor. The fourth factor consists of the highest loadings of Mexico and Finland, both of which are relatively small markets. The authors conclude that the Mexican and Finnish stock exchanges seemed to exhibit a price behavior of their own.

The main interpretation that Malkamaki, et. al. (1991) assigned to the four-factor model is geographic influence. Economic trade and currency areas seem to affect the risk of different stock markets. However, this explanation is not consistent with Mexico which is in North America but did not load on this factor. It is important to note that this study was made before NAFTA, and the correlation of Mexico with the U.S. and Canada after NAFTA would probably show an increase.

Contrasting with Malkamaki, et. al. (1991), and Errunza (1993), the paper of Soydemir (1997) studied the linkage between the markets of developed and emerging economies. The growing flow of portfolio investments to emerging economies suggests that this is an important question for international portfolio diversification. Using weekly data, he constructed a VAR model to investigate the extent of stock market interdependence between the markets of industrialized and emerging economies and found strong evidence of links between emerging and industrialized market returns. Although shocks are transmitted rapidly among developed markets, the spillovers are longer lasting in emerging markets. The U.S. market is found to be the most influential market affecting Latin American markets, with Argentina being

the least responsive and Mexico the most sensitive. The author suggests that these findings are congruent with the trade patterns that exist between these economies. Finally, he argues that stock market correlation increases over time and provides evidence in favor of greater stock market integration over the last years. There is a slight decrease in expected gains from diversification associated with the increase in correlation. These findings appear to be stronger for the Latin American countries and the U.S. relative to testing using the regional indices. The results indicate that globalization in financial flows has made the Latin American and U.S. stock markets more interdependent and less segmented.

c. Conclusion

The empirical evidence about Mexican stock behavior is not very consistent and covers small periods. On market efficiency, some authors (Junco and Sanchez, 1990; Hakim, 1992; and Johnson, 1992) argue that the efficient market hypothesis should be rejected and that trading opportunities disappear after high transaction costs are taken into account. In contrast, Ortiz (1980) maintains that opportunities exist for smart investors.

In other lines of research, Haugen, Ortiz, and Arjona (1985) found that in event studies, Mexican stock reaction to earnings announcements are higher than similar firms in the U.S., that the reaction occurs earlier, suggesting inside trading behavior. Herrera (1992) found that size and January anomalies are weaker or similar to those in the U.S. over the counter market.

Hakim (1992) and Johnson (1992) suggest that inefficiencies in the Mexican stock market are due to the lack of trading volume and information-related frictions. Nonetheless, Herrera (1992) suggests that the small number of informed participants in the market may reduce the intensity of the information-related frictions providing greater homogeneity in expectations of performance.

Related to pricing models, all the studies used the CAPM as a benchmark and the deviation of the CAPM affects their results. Jegadeesh (1998) proved that these types of studies are very sensitive to different benchmarks and that by using a characteristics-pricing model as a benchmark markedly reduces the abnormal effects obtained with the CAPM benchmark. Herrera (1992) used a multifactor model to explain seasonalities and found that his multifactor model was not an improvement over CAPM performance.

Errunza (1983) and Malkamaki, Martikainen, and Pertunnen (1991) argue that the return on the Mexican stock market has low correlation with the world market return, but in a recent paper Soydemir (1997) suggests that the correlation of Mexico with the world market and especially with the U.S. market is increasing. These results imply that the Mexican stock market is at least partially segmented, but that the segmentation may be reducing.

With respect to mutual funds, only Hakim (1992) mentioned that, in general, they cover the requirement that a well-diversified portfolio holds at least 16-20 different stocks.

Mexico is an interesting stock market, but it will be necessary to perform more research focused on market efficiency, stock return anomalies, event studies, and pricing models to gain more knowledge about its behavior.

CHAPTER 4

ECONOMETRIC TESTS FOR PRICING MODELS

I. INTRODUCTION

The objective of this chapter is to review empirical tests of the major asset pricing models within a unified framework. While the theory of financial asset pricing has essentially been in place for approximately two decades, there have been major advances in empirical methods over the same period. One of the major contributions of econometricians to the financial fields is the General Method of Moments (GMM). It is perhaps the most important innovation of this period since it unified previously used methods.

The vast majority of empirical work on asset pricing models has involved expected returns, stated in terms of beta coefficients relative to one or more coefficients. The beta is the regression coefficient of the asset returns on one or more factors. The concept of a minimum variance portfolio is central in this literature. The first model using this approach is the CAPM. However, empirical evidence rejects the CAPM. Trying to solve the minimum variance concept, multifactor equilibrium models have been developed.

In Section II, the CAPM is reviewed and the multivariate Wald and Likelihood Ratio (LR) tests are presented along with a discussion about their optimal size and power. In Section III, the most recent GMM tests are presented. In Section

IV the multifactor empirical tests in different versions are presented. The section focuses on the multifactor models that use mimicking factor trading portfolios and macroeconomic variables as factors. Section V briefly comments on other recent approaches to study the financial markets. Finally, section VI concludes the chapter.

II. THE CAPITAL ASSET PRICING MODEL (CAPM)

The most popular and well known asset pricing model is CAPM. In this section the theory behind the model and its assumptions are not reviewed, for such a review see Constantinides and Malliaris (1995). The focus here is on the test statistics that have been developed to measure to what degree the model fits the reality. In addition, a geometric explanation is included, along with a discussion about the size and power of the test.

a. The Model

In its original version the CAPM assumed the existence of lending and borrowing at a risk free rate of interest, formally expressed as:

$$E[R_i] = R_f + \beta_{im} (E[R_m] - R_f) \quad (1)$$

R_i is the return of asset i where $i = 1 \dots N$, R_m is the market return, R_f is the risk free return, and

$$\beta_{im} = \frac{Cov(R_i, R_m)}{Var(R_m)} \quad (2)$$

Another method to briefly express the CAPM uses excess returns, where Z_i is the difference between the return R_i and the risk free rate:

$$E[Z_i] = \beta_{im} E[Z_m] \quad (3)$$

$$\beta_{im} = \frac{Cov(Z_i, Z_m)}{Var(Z_m)} \quad (4)$$

If the risk free rate is treated as non-stochastic, equations (2) and (4) are equivalent. If the risk free rate is treated as stochastic, both betas could differ.

The CAPM is a single-period model. For econometric analysis it is necessary to add some assumptions about time series behavior. The basic assumptions are that the returns are identically and independently distributed, (i.i.d.), through time and jointly multivariate normal.

b. Estimation and Testing of the CAPM

The test considered here requires that the number of assets under study always be less than the number of time series observations. This restriction is imposed so that the sample covariance matrix remains non-singular.

To estimate the CAPM, expected returns, $E(Z_t)$, are needed, whereas only actual returns, Z_t , are observed. This implies that additional assumptions about the relationship between expected and actual returns are required. The weak-form of the Efficient Market Hypothesis (EMH) implies that trend analysis does not convey reliable signals about future performance and the best estimator of the expected returns is the actual returns $E(Z_{t+1})=Z_t$. For more details see Fama (1970) and Malkiel (1990). To estimate the joint hypothesis of the CAPM and the weak-form of the EMH:

$$Z_t = \alpha + \beta Z_{mt} + \varepsilon_t \quad (5)$$

where Z_t is a vector that contains excess returns of the N assets in time t , β is the $(N \times 1)$ vector of betas, Z_{mt} is the excess return of the market in time t , α is the $(N \times 1)$ vector of intercepts and ε_t is the $(N \times 1)$ vector of disturbance of each asset in time t .
By definition:

$$\begin{aligned} E[\varepsilon_t] &= 0 & E[\varepsilon_t \varepsilon_t'] &= \Sigma & E[Z_{mt}] &= \mu_m & E[Z_t] &= \mu \\ & & Var[Z_{mt}] &= \sigma_m^2 & Cov[Z_{mt}, \varepsilon_t] &= 0. & & \end{aligned}$$

Another important assumption in the econometric estimation of the CAPM is the independence among the market portfolio proxy and the ε_t , β , and α . The implication

of the Sharpe version of the CAPM, equation (5), and the weak-form of the EMH is that α is zero in all its elements. This follows from comparing equation (5) with equation (3) and forms the principal hypothesis of the model. If all elements of α are zero, then the market portfolio proxy is the tangency portfolio.

In a first approach, Lintner (1965) estimated betas for separate time series regressions in each asset. Mean returns are computed for each asset and α and Z_m are estimated from a second pass cross-sectional regression (CSR) from equation (5). Despite the fundamental role played by this methodology, not much is known about its statistical properties. Since the independent variable in the CSR is measured with error, the second pass estimator is subject to errors-in-variables (EIV) problems, causing bias in small samples. Additionally, inference is complicated since empirical evidence suggests that securities returns are cross-sectional and serially correlated. Shanken (1992) argues that as the time series observations, T , increase to infinite, the second pass estimator is consistent. However, the fact that within the limit the errors disappear does not mean it can be ignored even in large sample inference. Therefore, a conclusion based on two-pass regressions in equation (5) can be misleading.

Fama and MacBeth (1973) introduced an alternative technique to estimate the precision of CSR estimates. They estimated rolling betas with several years of monthly information prior to the current month and ran the CSR of returns with these betas in each month of the sample period. In this way, a time series of estimates is generated for α and Z_m . Their sample means were taken as final estimates and

standard errors are computed as if they were i.i.d., with mean α and Zm . However, the measurement error in the overlapping beta estimates induces bias. Shanken (1992) argued that this Fama-MacBeth procedure fails to reflect measurement errors in the betas and overstates the precision of the α and Zm estimates. However, Shanken (1992) recognized that the overlapping method is an improvement over the two-pass method.

Gibbons (1982) developed a Maximum Likelihood (MLH) estimation for equation (5) in that both parameters are estimated at the same time, eliminating the EIV problem. Although Gibbon's claim that the MLH is intuitively reasonable, it has not been proved. The precise sense in which the problem is eliminated is not clear. Shanken (1992) pointed out that the standard asymptotic properties of this approach are shared by the second-pass method. In the following subsection, the most recent one-pass multivariate tests are presented.

c. The Multivariate Wald and Likelihood Ratio Tests

The Wald test is based on the OLS and MLH estimators (that in this case are similar) of α and β of equation (5), with a null hypothesis, $H_0: \alpha=0$ against the alternative, $H_a: \alpha \neq 0$. The Wald test statistic is defined formally as follows:

$$W_0 = \alpha_T^T [\text{Var}(\alpha_T)]^{-1} \alpha_T \sim \chi^2_N$$

$$= T \left[1 + \frac{\mu_{mT}^2}{\sigma_{mT}^2} \right]^{-1} \alpha_T^T \Sigma^{-1} \alpha_T \quad (6)$$

It has a chi-square distribution with N degrees of freedom. However, the covariance matrix is not known and should be estimated with a consistent Σ_T . It is not necessary to use large-sample distribution theory to draw inferences using a Wald-type test. MacKinlay (1987) and Gibbons, Ross, and Shanken (1989) developed the finite-sample distribution properties. They adjust the traditional Wald test and prove that its distribution is a center F with N degrees of freedom in the numerator and $(T-N-1)$ degrees of freedom in the denominator, formally:

$$W_a = \frac{(T - N - 1)}{N} \left[1 + \frac{\mu_{mT}^2}{\sigma_{mT}^2} \right]^{-1} \alpha_T^T \Sigma^{-1} \alpha_T \sim F_{N, (T-N-1)} \quad (7)$$

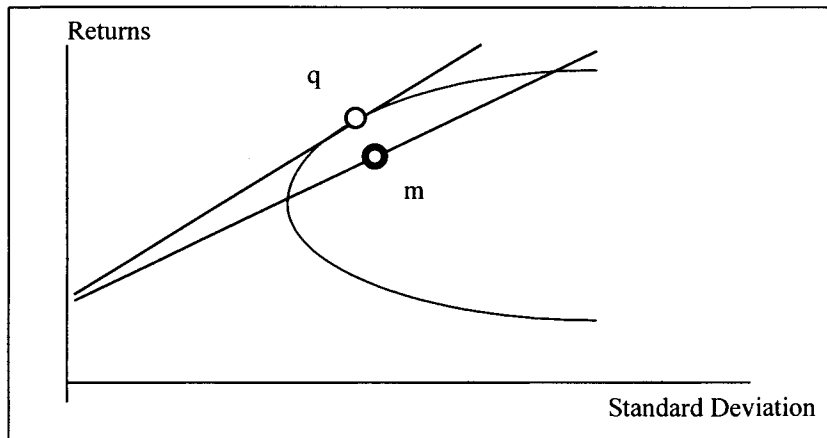
The Wald adjusted test or finite-sample test, W_a , can be constructed using only the estimators of the unconstrained model. Generally, the normality assumption has been viewed as providing a good approximation to the distribution of monthly stock returns. There is some evidence that the true distributions are slightly leptokurtic relative to the normal distribution. While departures from normality will affect the small-sample distribution of the test statistic, simulation evidence by MacKinlay

(1995) suggests that the F test is fairly robust to such misspecifications. Gibbons, Ross, and Shanken (1989) show that:

$$W_a = \frac{(T - N - 1)}{N} \left[\frac{\frac{\mu_q^2}{\sigma_q^2} - \frac{\mu_m^2}{\sigma_m^2}}{1 + \frac{\mu_m^2}{\sigma_m^2}} \right] \quad (8)$$

where the portfolio q , represents the ex post tangency portfolio constructed with N assets plus the market portfolio. Recall that the portfolio with the maximum squared Sharpe ratio of all portfolios is the tangency portfolio. Then when the ex post market

FIGURE 3
Geometric Explanation of a Wald Test



portfolio, m , is the tangency portfolio, q , the W_a test is zero. If the Sharpe ratio of the market decreases, W_a will increase, indicating strong evidence against the efficiency of the market portfolio, (see Figure 3).

MacKinlay (1987) suggests that the test improves substantially if the unconstrained model is compared against a constrained model. He develops a version of the LR test. The constraint is $\alpha=0$, and the estimators are:

$$\beta^*_T = \frac{\sum_{t=1}^T Z_t Z_{mt}}{\sum_{t=1}^T Z_{mt}^2} \quad (9)$$

$$\Sigma^*_T = \frac{1}{T} \sum_{t=1}^T (Z_t - \beta^*_T Z_{mt})(Z_t - \beta^*_T Z_{mt})^T \quad (10)$$

This test is based on the logarithm of the LR, which is the value of the unconstrained log-likelihood minus the unconstrained log-likelihood function evaluated at the MLH estimators, formally:

$$LR_0 = L^* - L = -\frac{T}{2} \left[\log |\Sigma_T^*| - \log |\Sigma_T| \right] \quad (11)$$

MacKinlay (1987) and Gibbons, Ross, and Shanken (1989), prove that under the null hypothesis, -2 times the LR_0 is distributed chi-square with degrees of freedom equal to the number of restrictions under H_0 :

$$LR_2 = T \left[\log |\Sigma_T^*| - \log |\Sigma_T| \right] \sim \chi_N^2 \quad (12)$$

They show that W_a is a monotonic transformation of LR_2 and it is not necessary to use large-sample theory to conduct the LR_2 test. Formally, the relationship between W_a and LR_2 is:

$$W_a = \frac{(T - N - 1)}{N} \left(\exp \left[\frac{LR_2}{T} \right] - 1 \right) \quad (13)$$

This shows that the Wald test adjusted to finite-sample W_a , can be interpreted as an LR adjusted test. Since the distribution of W_a is known, with equation (13), we can infer the distribution of LR_2 . However, Jobson and Korkie (1983) suggest an adjustment to LR_2 that has better finite-sample properties. This LR_2 adjusted test is:

$$LR_3 = \left(T - \frac{N}{2} - 2 \right) LR_2 = \left(T - \frac{N}{2} - 2 \right) \left[\log |\Sigma_T^*| - \log |\Sigma_T| \right] \sim \chi_N^2 \quad (14)$$

The main advantage of these tests is that both eliminate the EIV bias. Nonetheless, both rely on the assumption of i.i.d. returns, and empirical evidence exists that is

contrary to this assumption. Section II will review a method that deals with these problems.

d. The Size of the Test

In the literature, there is no precise rule about the correct size of a sample for the asymptotic results to provide a good approximation. However, by using the known finite-sample distribution of the W_a test, Campbell, Lo, and MacKinlay (1997) calculate the large sample size of W_o , LR_2 and LR_3 and then they calculate the exact value of a W_a test for five percent. With this value and the known relationships among these tests, W_o , LR_2 , LR_3 , and W_a , they estimate the percentage of rejection for different time series observations. For instance, for a series of 60 observations and ten portfolios, W_o is 17 percent, which means that W_o rejects the null hypothesis more than three times too often. Campbell, Lo, and MacKinlay perform a table varying the sample size using 60, 120, 180, and 360 monthly time series observations and 10, 20, and 40 portfolios. In all cases using the large sample test W_o , LR_2 and LR_3 , are rejected too often. This problem is severe in short samples. In 60 observations and ten portfolios, the W_o and LR_2 rejection is tripled and doubled, respectively. However they improve to 6.4 and 5.6 percent when the sample increases to 360 observations. In all cases, the increments of observation improve the test and increasing the number of portfolios reduces its accuracy. LR_3 performs much better than its unadjusted counterpart. In the worst case (60 observations and 40 portfolios) it was 1.4 percent and in the rest of the combinations the results were in

the five percent range. The authors conclude that when using the adjusted test, a sample of ten portfolios and 60 observations could be sufficient.

e. Power of the Test

The power of the test is the probability that the null hypothesis will be rejected given that an alternative hypothesis is true. Lower power indicates that the test is not useful to discriminate between the null and the alternative hypothesis. However, if the power is high it may reject the null frequently and the problem can be due to small unimportant deviations from the null. The power for a given size of test is the probability that the test statistic is greater than the critical value under the null hypothesis, given that the alternative hypothesis is true. MacKinlay (1987) argues that the majority of the work in testing the CAPM has been focused in the testable implications of the model and relatively little attention has been given to power considerations. An exception is Gibbons, Ross, and Shanken (1989). They present some results for the test of the efficiency of a given portfolio. Besides the lack of attention to this topic there are indications that these tests may have low power. MacKinlay (1987) suggests that with an unspecified alternative hypothesis, an important determinant of the power is the type of deviation present. The test can have reasonable power if the deviation is random across assets. But if the deviation is the result of missing factors, the tests are weak. The distance will be relatively small for reasonable missing factor parameters. Additionally, MacKinlay (1987) argues that power gains are possible by introducing a specific alternative hypothesis. Using a

specific alternative hypothesis, he rejects the Sharpe's CAPM. He suggests that power increases with more time series observations and decreases when the number of portfolios is incremented. However, if the number of observations are increased due to an increase in the frequency (use of daily data instead of monthly), there are strains on the normality and independence assumptions and it is not recommended. Finally, he suggests that the distribution of the test statistic in an APT world is likely not to be very different from the distribution in a CAPM world making the rejection of the CAPM evidence in favor of the APT, without further investigation, inappropriate.

In order to test the power of the CAPM tests, Campbell, Lo, and MacKinlay (1997) focused on the W_a . They consider that the power of this test is representative since the exact finite-sample distribution of W_a is known under both the null and alternative hypotheses. There is no clear rule about the optimal design of a multivariate test, but some insights are drawn from this empirical study. In general, the power is reduced when the number of portfolios is increased. This number should be kept small, perhaps no larger than ten. Increases in power are possible with large samples. The power increases from 0.082 to 0.380 by increasing the observations from 60 to 360 (both cases with ten portfolios). Combining the results of the former and this section, a general rule of thumb could be that the test should be made with ten portfolios and the maximum number of time series observation available with a minimum of 60.

II. THE GMM AND THE PRICING MODELS

Up to this point, the assumptions have been that returns are jointly normal and i.i.d. through time. However, since Fama (1965), there is evidence that deviations from these assumptions exist. Hawawini and Keim (1995) present a review of evidence against the assumptions. This section will consider a test that accommodates non-normality, heteroskedasticity, and temporal dependence or serial correlation of returns. The reason for a study of this type of test is that the CAPM, as a theoretical model, does not rest on the normality assumption and is a one period model. It does not make any assumptions on distributions through time. Rather, the normality assumption is adopted for statistical purposes. Without this assumption, the finite-sample properties of the CAPM test are difficult to derive. It is therefore important to consider the effects of relaxing these statistical assumptions. A robust test of the CAPM can be constructed using a GMM framework and the distribution of the returns can be both serially dependent and conditionally heteroskedastic. It is only necessary to assume that the excess asset returns are both stationary and ergodic with finite fourth moments.

a. CAPM Estimators with GMM

The GMM developed by Hansen (1982) is one of the most important advances in econometrics in the last two decades. It embraces the OLS, the MLH, and the instrumental variable methods. A detailed explanation of the GMM can be found in Ogaki (1993), Hall (1993), and Hamilton (1994) and it will not be reviewed in the

present study. This section will only review the GMM applications to develop CAPM tests.

The first step is to set up the vector of moment conditions with zero expectation. The required moment conditions follow from the excess-return market model. The residual vector provides N moment conditions, and the product of the excess return of the market and the residual vector provides another N moment conditions:

$$F(X_t, \Theta) = h_t \otimes \varepsilon_t \tag{15}$$

where \otimes is the Kronecker product and:

$$h_t^T = [1, Z_{mt}] \quad \varepsilon_t = Z_t - \alpha - \beta Z_{mt} \quad \Theta^T = [\alpha^T \beta^T]$$

making F a $(2N \times 1)$ moment condition vector. The specification of the CAPM equation (15) implies that the moment condition is $E[F(X_t, \Theta_0)]$ where Θ_0 is the true parameter vector. This moment condition forms the basis for estimation and testing with a GMM approach. The first step is to force the parameter to carry out the moment restriction by minimizing a quadratic form of the sample means:

$$J_T(\Theta) = \left(\frac{1}{T} \sum_{t=1}^T F(X_t, \Theta) \right)' W_T \left(\frac{1}{T} \sum_{t=1}^T F(X_t, \Theta) \right) \quad (16)$$

with respect to Θ where W is the distance or weighting matrix. The GMM estimator Θ_T is the solution to the minimization problem, equation (16). However, it is necessary to have a consistent estimator for the weighting matrix. In this specific case the weighting matrix W_T is a $(2N \times 2N)$ matrix. It is important to note that if the system has $2N$ moment conditions and $2N$ unknown parameters to estimate, then the system is exactly identified. Then Θ_T are the parameters which solve the next equation:

$$\lim_{T \rightarrow \infty} \frac{1}{T} \sum_{t=1}^T F(X_t, \Theta) = E[F(X_t, \Theta)] \quad (17)$$

In this case the GMM estimators are independent of the weighting matrix, and the parameters are equivalent to the MLH and OLS estimators. The difference between the GMM approach and the MLH or OLS is the robustness of the covariance matrix. As explained previously, the covariance matrix of the excess returns is adjusted to heteroskedasticity and serial correlation. The variance of the estimated parameters α_T and β_T will differ from the variance in the MLH approach. The variance matrix of the parameters is $V(\Theta_T)$ where:

$$V(\Theta_T) = [\Gamma^T \Omega^{-1} \Gamma]^{-1} \quad (18)$$

and Γ and Ω are defined respectively:

$$\Omega = \lim_{j \rightarrow \infty} \sum_{-j}^j E(F(X_t, \Theta)_t F(X_t, \Theta)_{t-j}^T) \quad (19)$$

$$\Gamma = E\left(\partial \frac{1}{T} \sum F(X_t, \Theta) / \partial \Theta^T\right) \quad (20)$$

Assuming that the asymptotic distribution of Θ_T is normal we have:

$$\Theta_T \sim N\left(\Theta, \frac{1}{T} [\Gamma^T \Omega^{-1} \Gamma]^{-1}\right) \quad (21)$$

Equation (21) implies consistent estimators of Γ and Ω . A consistent estimator of Γ

is proposed by Campbell, Lo, and MacKinlay (1997):

$$\Gamma_T = - \begin{bmatrix} 1 & \mu_{m,T} \\ \mu_{m,T} & (\sigma_{m,T}^2 + \mu_{m,T}^2) \end{bmatrix} \otimes I_N \quad (22)$$

Where μ is the expected excess return. To calculate a consistent estimator of Ω , an assumption is necessary to reduce the infinite terms in the equation (19) to a finite number of terms. Newey and West (1987) suggest that within the GMM, estimation of Ω is the more difficult task and is also the more important. They comment that the simplest estimator is:

$$\Omega_T = \Phi(0) + \sum_{\tau=1}^m [\Phi(\tau) + \Phi(\tau)^T] \quad (23)$$

where $\Phi(\tau)$ and $\Phi(0)$ are defined as:

$$\Phi(\tau) = \frac{1}{m} \sum_{t=\tau+1}^m F(X_t, \Theta_T) F(X_{t-\tau}, \Theta_T)^T \quad \text{for } \tau > 0 \quad (24)$$

$$\Phi(0) = \frac{1}{m} \sum_{t=1}^m F(X_t, \Theta_T) F(X_t, \Theta_T)^T \quad (25)$$

The bound m in equations (24) and (25) is equal to the number of nonzero autocorrelations of $F(X, \Theta)$, which is known a priori. However, in many cases this number is unknown a priori and may not even be finite. In such cases, Ω may still be consistently estimated by Ω_T (i.e., $\Omega_T - \Omega \rightarrow 0$) if m is chosen to be a function $m(T)$ of sample size and is allowed to grow slowly with the sample size. Hamilton (1994) provides a useful overview of other estimators.

b. GMM Tests of the CAPM

There are two tests based on the GMM that are often shown in the literature that reviews testing asset pricing models. The first is a generalization of the Wald test, the second is analogous to the LR test statistic. In the Wald test, the null is $\theta=0$, choosing Ω_T as a consistent estimator of Ω . Newey and West (1987) constructed a chi-square test for the CAPM model and the test is:

$$G_w = T\alpha_T^T \left[R \left(\Gamma_T^T \Omega_T^{-1} \Gamma_T \right)^{-1} R^T \right]^{-1} \alpha_T \sim \chi_N \quad (26)$$

where

$$R = (1,0) \otimes I_N$$

The standard CAPM test statistics can be biased from violations of the distribution assumptions. MacKinlay and Richarson (1991) discussed the magnitude of this problem, and showed that if the Sharpe ratio is high and the degrees of freedom small, the bias can be substantial and lead to incorrect inferences. Calculation of the G_w statistic based on the GMM provides a simple check to insure that the rejection of the CAPM is not due to heteroskedasticity and serial correlation in the data.

The LR approach is discussed in Gallant (1987). He assumed that the null hypothesis implies the orthogonality conditions hold:

$$E[F(X_t, \Theta_0)] = 0 \quad (27)$$

while under the alternative subset:

$$E[F^*(X_t, \Theta_0)] = 0 \quad (28)$$

Equation (27), unrestricted, is based on equation (5) and equation (28), restricted, is based on equation (3). Estimating the model under the null hypothesis, the quadratic form:

$$\left(\frac{1}{T} \sum_{t=1}^T F^*(X_t, \Theta) \right)^T W^* \left(\frac{1}{T} \sum_{t=1}^T F^*(X_t, \Theta) \right) \quad (29)$$

is minimized. Let W_{11}^* be the inverse of the upper left block of W^{*-1} . Holding this matrix fixed, the model is estimated under the alternative by minimizing:

$$\left(\frac{1}{T} \sum_{t=1}^T F(X_t, \Theta) \right)^T W_{11}^* \left(\frac{1}{T} \sum_{t=1}^T F(X_t, \Theta) \right) \quad (30)$$

The LR test (D), is the difference of the two quadratic forms and is asymptotically chi-square with degrees of freedom equal to N , formally:

$$D = T \left(\frac{1}{T} \sum_{t=1}^T F^*(X_t, \Theta) \right)^T W_{11}^* \left(\frac{1}{T} \sum_{t=1}^T F^*(X_t, \Theta) \right)$$

$$-\left(\frac{1}{T} \sum_{t=1}^T F(X_t, \Theta)\right)^T W_{11T} \left(\frac{1}{T} \sum_{t=1}^T F(X_t, \Theta)\right) \quad (31)$$

Simulation studies find that the asymptotic standard errors given by equation (31) are likely to be understated in small samples (Ferson and Foerster, 1994). In practice, it may be desirable to adjust with the next factor

$$D_A = D * T / (T - P) \quad (32)$$

where P is the number of parameters.

The main advantage of these two GMM-based tests is that they are one pass multivariate tests and do not have EIV related bias. In addition, they do not depend on normality, homoskedasticity, or independence assumptions of the returns. The main disadvantage of the GMM tests is that they are asymptotically efficient.

IV. MULTIFACTOR PRICING MODEL

Empirical research during the last twenty years has rejected the joint hypothesis of market efficiency and CAPM, encouraging the development of multifactor alternative models. In this section, the econometric tests for a multifactor pricing model are developed independently if the model originated from Merton (1973), Ross (1976), or other pricing models that utilize a multifactor approach:

$$R = a + Bf + e \quad (33)$$

where $E[ef] = 0$ and $E[ee^T] = \Sigma$

In this equation system R is an $(N \times 1)$ vector of the N assets returns, a is the $(N \times 1)$ vector of intercepts, f is a $(k \times 1)$ vector of the k risk factors, B is the $(N \times k)$ matrix of betas or sensitivities slopes, and finally e is the $(N \times 1)$ vector of disturbances. It is assumed that the disturbance term e is uncorrelated across assets. This implies that in efficient markets:

$$\mu = i\lambda_0 + B\lambda_k \quad (34)$$

where μ is the $(N \times 1)$ vector of the N assets expected returns, i is a $(N \times 1)$ one's vector, λ_0 is the risk free or zero-beta parameter, and λ_k is the $(k \times 1)$ vector of factor risk premium. The basic assumption about the time-series behavior of the returns is that conditional to the factors, realizations are i.i.d. through time and jointly multivariate normal. This assumption will be relaxed with the GMM.

A general approach for multifactor models is the likelihood ratio. The general form of this test is:

$$LRm = -\left(T - \frac{N}{2} - K - 1\right) [\log|\Sigma_T| - \log|\Sigma_T^*|] \sim \chi_N^2 \quad (35)$$

where T is the number of time-series observations, N is the number of portfolios, K is the number of factors, and Σ_T and Σ_T^* are the maximum likelihood estimators of the residual covariance matrix for the unconstrained and constrained model, respectively. $(T-N/2-K-1)$ is used instead of T to improve convergence of the finite-sample null distribution to the large sample distribution (Jobson and Korkie, 1982). The distribution of LR_m under the null hypothesis will be chi-square with a degree of freedom equal to the number of restrictions imposed by the null hypothesis.

a. Estimating Factors

Basically, there are three ways to estimate the factors in a multifactor model. Statistical procedures exist, such as factor analysis and component analysis, traded portfolios mimicking firm characteristics, and macroeconomic variables like interest rates and economic activity changes.

The statistical methods provide the best estimates of the factors given the model's assumptions, but the assumption that the covariance is constant is crucial and probably is violated in reality. Besides, the statistical methods do not "name" the factors, and this does not shed any intuition into which economic variables are linked to risk. In other words, the factors are not theoretically founded.

Lehmann and Modest (1987) and Connor and Korajczyk (1986) have used factor analysis and principal component models respectively to test the multifactor model. In this section, the pure factor statistical methods have not been described

since they seem to be downward biased. Using a factor analysis model as benchmark, Lehmann and Modest (1987) found that mutual funds under performed (four percent on average), their expected return. Daniel and Titman (1997) argue that this effect is due to the fact that the risk characteristic is time-varying as a firm moves in and out of distress. This means that an experiment that estimates the factors using a purely statistical factor or principal components analysis would give invalid results (moreover, if after the factoring exercise a determination of the premium of risk is undertaken, the experiment would not be appropriate). Since there is not group of firms that continually loads on the distress factor, the factor cannot be extracted with a purely statistical factor analysis.

The second approach is characteristics-sorted traded portfolios or mimicking factor portfolios. The intuition behind this technique is as follows: if the risk premium associated with a characteristic (size, BE/ME, leverage and others) represents compensation for a specific kind of factor risk, then portfolios of stocks with that characteristic are likely to be highly correlated with that specific source of risk. Given that covariances could change over time, portfolios formed in this way (when a specific stock changes its characteristic, it is moved to its correspondent portfolio) capture the dynamics, thus providing better proxies for these common factors than portfolios formed with factor analysis. In this technique each portfolio is rebalanced periodically maintaining its characteristics constant through time. The individual stocks characteristic could be time varying, but portfolio characteristics remain constant. Then this multifactor technique accommodates to parametric

techniques. In addition, the precision and timing in the information of characteristics of each stock is better than the general macroeconomic information. In the mimicking factor approach, Fama and French (1992, 1993) and recently Carhart (1997) present a comprehensive study that describes the use of this technique.

Finally, macroeconomic variables are used to estimate the factors. This approach uses a large set of variables such as unemployment, inflation, interest rates, and GDP. Chen, Roll, and Ross (1986) is a pioneering study of multifactor testing using macroeconomic variables as factors. The main advantage of macroeconomic variables as factors is the clear economic intuition that they provide. However, this technique implies that the appropriate factors are the unanticipated changes in the macroeconomic variables and it may be difficult to measure in practice. Besides, in countries like Mexico, economic information normally is delayed and continuous corrections and adjustments appear in consequent years, making it a difficult task for a researcher to implement precise multifactor models.

In the present research the traded mimicking factor portfolio is mainly used. However, as a second test to corroborate the results from the mimicking factor portfolio tests, macroeconomic variables as factors are used too.

b. Traded Mimicking Factor Portfolios.

In this case the factors are traded mimicking factor portfolios and the risk free asset. The unconstrained model will be a K -factor expressed in excess returns:

$$Z_t = a + B Z_{mt} + \varepsilon_t \quad (36)$$

where

$$E[\varepsilon_t] = 0 \quad E[\varepsilon_t \varepsilon_t'] = \Sigma \quad E[Z_{kt}] = \mu_k \quad E[Z_t] = \mu$$

$$\text{Cov}[Z_{kt}, \varepsilon_t] = O \quad E[(Z_{kt} - \mu_k)(Z_{kt} - \mu_k)^T] = \Omega_k$$

and Z_t is the $(N \times 1)$ vector of excess returns for N portfolios (or assets) in time t . B is the $(N \times K)$ matrix of factor sensitivities, Z_{kt} is the $(k \times 1)$ vector of factor portfolios excess returns in time t , a is a $(N \times 1)$ vector of intercepts, and ε_t is the $(N \times 1)$ disturbance in time t . Σ is the covariance matrix of disturbance, Ω_k is the covariance matrix of the factor portfolios excess returns, and O is a $(K \times n)$ matrix of zeroes. The exact factor pricing implies that the elements of the vector a in equation (36) will be zero. The maximum likelihood estimators for the unconstrained model are the OLS estimators:

$$a_T = \mu_T - B_T \mu_{T,M} \quad (37)$$

$$B_T = \left[\sum_{t=1}^T (Z_t - \mu_T)(Z_{kt} - \mu_k)^T \right] \left[\sum_{t=1}^T (Z_{kt} - \mu_{k,T})(Z_{kt} - \mu_{k,T})^T \right]^{-1} \quad (38)$$

$$\Sigma_T = \frac{1}{T} \sum_{t=1}^T (Z_t - a_T - B_T Z_{kt})(Z_t - a_T - B_T Z_{kt})^T \quad (39)$$

where

$$\mu_T = \frac{1}{T} \sum_{t=1}^T Z_t \quad \text{and} \quad \mu_{k,T} = \frac{1}{T} \sum_{t=1}^T Z_{kt}$$

Constraining a_T to be equal to zero, the estimators are:

$$B_T^* = \left[\sum_{i=1}^T Z_i Z_{K_i}^T \right] \left[\sum_{i=1}^T Z_{K_i} Z_{K_i}^T \right]^{-1} \quad (40)$$

$$\Sigma_T^* = \frac{1}{T} \sum_{i=1}^T (Z_i - B_T^* Z_{K_i})(Z_i - B_T^* Z_{K_i})^T \quad (41)$$

The null hypothesis, $a_T = 0$, can be tested with the LR_m test (equation, 35) and the degrees of freedom should be N since the null imposes N restrictions.

Another alternative test is an exact multivariate F-test of the null hypothesis.

Defining Wm_a as the Wald moment adjusted test statistic:

$$Wm_a = \frac{(T - N - K)}{N} \left[1 + \mu_{KT}^T \Omega_{KT}^{-1} \mu_{KT} \right]^{-1} a_T^T \Sigma^{-1} a_T \sim F_{N, (T-N-K)} \quad (42)$$

where Ω_{KT} is the maximum likelihood estimator of Ω_K ,

$$\Omega_{KT} = \frac{1}{T} \sum_{i=1}^T (Z_{K_i} - \mu_K)(Z_{K_i} - \mu_K)^T \quad (43)$$

This test can be useful since it can eliminate the problems that may accompany the use of asymptotic distribution theory. Derivation of this test is presented in Jobson and Korkie (1982).

Another important task is the estimation of risk premium and expected returns. Since the expected return relation is $\mu = i\lambda_0 + B\lambda_K$, one needs an estimate of B , the risk free rate λ_0 , and the factor risk premium λ_K . Equation (38) is used to obtain B . The observed risk free rate is appropriated for λ_0 . Further, it is necessary to form estimates of the factor risk premium λ_K . The appropriate procedure for factors formed with traded mimicking factor portfolios is to estimate the risk premium directly from the sample means of the excess returns on the portfolios. Formally

$$\lambda_{KT} = \mu_{KT} = \frac{1}{T} \sum_{t=1}^T Z_{Kt} \quad (44)$$

and an estimator of the variance is:

$$\text{Var}_T[\lambda_K] = \frac{1}{T} \Omega_K = \frac{1}{T^2} \sum_{t=1}^T (f_{Kt} - \mu_K)(f_{Kt} - \mu_K)^T \quad (45)$$

It is of interest to test if the factors are jointly priced. Given the vector of risk premium estimates λ_K , and its covariance matrix, $\text{Var}_T[\lambda_K]$, a test of the null hypothesis is:

$$HT_a = \frac{(T-K)}{TK} \lambda_{KT}^T \text{Var}_T[\lambda_{KT}]^{-1} \lambda_K \sim F_{K, T-K} \quad (46)$$

This test is an application of the Hotelling T^2 statistic and will be exact in finite samples for the cases where the estimator λ_k is based only on the sample means of the factors.

Another important test is the significance of an individual factor using:

$$t = \frac{\lambda_{jKT}}{\sqrt{v_{jj}}} \sim N(0,1) \quad (47)$$

where λ_{jKT} is the j th element of the λ_{KT} vector and v_{jj} is the (j,j) th element of the $\text{Var}_T[\lambda_K]$, matrix. This test is relevant when factors have been theoretically specified.

c. Macroeconomic Variables

The factors do not necessarily need to be traded portfolios. Merton(1973) proposes macroeconomic variables such as innovations in GNP, inflation, or bond yields. In these multifactor models the use of real returns is common (R_t vector of $(N \times 1)$):

$$R_t = a + B f_{kt} + \varepsilon_t \quad (48)$$

where $E[\varepsilon_t] = 0$ $E[\varepsilon_t \varepsilon_t'] = \Sigma$ $E[f_{kt}] = \mu_K$ $E[R_t] = \mu$

$Cov[f_{kt}, \varepsilon_t] = 0$ and $E[(f_{kt} - \mu_K)(f_{kt} - \mu_K)'] = \Omega_K$

B is the $(N \times K)$ matrix of factor sensitivities, f_{kt} is the $(k \times 1)$ vector of factor realizations, a is a $(N \times 1)$ vector of intercepts, and ε_t is the $(N \times 1)$ disturbance in time t . Σ is the covariance matrix of disturbance, Ω_K is the covariance matrix of the factor portfolios excess returns, and O is a $(K \times n)$ matrix of zeroes. The MLH estimator for the unconstrained model is:

$$a_T = \mu_T - B_T \mu_{T,M} \quad (49)$$

$$B_T = \left[\sum_{t=1}^T (R_t - \mu_T)(f_{kt} - \mu_K)' \right] \left[\sum_{t=1}^T (f_{kt} - \mu_{K,t})(f_{kt} - \mu_{K,t})' \right]^{-1} \quad (50)$$

$$\Sigma_T = \frac{1}{T} \sum_{t=1}^T (R_t - a_T - B_T f_{kt})(R_t - a_T - B_T f_{kt})' \quad (51)$$

where

$$\mu_T = \frac{1}{T} \sum_{t=1}^T R_t \quad \text{and} \quad \mu_{K,T} = \frac{1}{T} \sum_{t=1}^T f_{kt}$$

The constrained model is formulated by comparing equation (48) with equation (34), then the unconditional expectation of equation (48) is:

$$\mu = a + B \mu_K \quad (52)$$

where $\mu_{f_K} = E[f_{K_t}]$. From equation (34) and (52):

$$a = i\lambda_0 + B(\lambda_K - \mu_{f_K}) \quad (53)$$

where λ_0 is the risk free asset. From equation (48) and (53) we have:

$$R_t = i\lambda_0 + B(\lambda_K - \mu_{f_K}) + B f_{K_t} + \varepsilon_t \quad (54)$$

the constrained model estimators are:

$$B_T^* = \left[\sum_{t=1}^T (R_t - i\lambda_0)(f_{K_t} + \lambda_K - \mu_{f_K})^T \right] \times \left[\sum_{t=1}^T (f_{K_t} + \lambda_K - \mu_{f_K})(f_{K_t} + \lambda_K - \mu_{f_K})^T \right]^{-1} \quad (55)$$

$$\Sigma_T^* = \frac{1}{T} \sum_{t=1}^T (R_t - i\lambda_0 - B_T^*(f_{K_t} + \lambda_K - \mu_{f_K}))(R_t - i\lambda_0 - B_T^*(f_{K_t} + \lambda_K - \mu_{f_K}))^T \quad (56)$$

If we define $\gamma_0 = \lambda_0$, $\gamma_1 = \lambda_K - \mu_{f_K}$ and $\gamma = [\gamma_0 \ \gamma_1^T]^T$ and $X = [iB_T^*]$, then:

$$\gamma_T = \left[X^T \Sigma_T^{*-1} X \right]^{-1} \left[X^T \Sigma_T^{*-1} (\mu_T - B_T^* \mu_{f_K}) \right] \quad (57)$$

The MLH estimates can be obtained by iterating over (55) to (57). Equations (50) and (51) can be used as starting values. The estimator of its variance is

$$Var_T[\gamma_T] = \frac{1}{T} (1 + (\gamma_{1T} + \mu_{JK})^T \Omega_{KT}^{-1} (\gamma_{1T} + \mu_{JK})) [X^T \Sigma_T^{-1} X]^{-1} \quad (58)$$

This variance will be used to test the factor risk premium.

There are several ways to iterate over several equations. One-step weighting matrix/iterate coefficients, one-step weighting matrix/one-step coefficients, iterate weights and coefficients/sequentially, and iterate weights and coefficients/simultaneously. All these iteration techniques yield results that are asymptotically efficient. For linear models, the two iterate weights and coefficients techniques are equivalent to each other, and the two one-step weighting matrix techniques are equivalent to each other, since obtaining coefficient estimates does not require iteration. Then, using at least two of the iterative techniques to check that the estimated parameters are the same is recommended. The difference in the estimated parameters among different iterative techniques could be the result of small samples, where asymptotically efficiency is not achieved.

Another important question to consider when macroeconomic variables are used is the correlation among different factors. When factors are not correlated, the coefficient of each factor represents the sensibility of the dependent variable to each factor, but when correlation exists this meaning is distorted. Then it is recommended

to do an orthogonalization process among the factors. This is achievable through regression of each variable with the rest of the model. The innovation of this regression is the orthogonal factor. See Elton and Gruber (1991) for a detailed explanation of this process. The most important result is that in an orthogonal multifactor model all the factors have zero correlation with each other and the coefficients have a clear economic meaning.

d. The GMM in Multifactor Models

The GMM tests in multifactor models are similar to the test in a single factor CAPM:

$$Gmm = T\alpha_T^T \left[R \left(\Gamma_T^T \Omega_T^{-1} \Gamma_T \right)^{-1} R^T \right]^{-1} \alpha_T \sim \chi_N \quad (59)$$

$$D = T \left(\frac{1}{T} \sum_{t=1}^T F^*(X_t, \Theta) \right)^T W_{11T}^{-1} \left(\frac{1}{T} \sum_{t=1}^T F^*(X_t, \Theta) \right) - \left(\frac{1}{T} \sum_{t=1}^T F(X_t, \Theta) \right)^T W_{11T} \left(\frac{1}{T} \sum_{t=1}^T F(X_t, \Theta) \right) \quad (60)$$

identical to the CAPM tests. The only difference is in the orthogonal conditions equation:

$$F(X_t, \Theta) = h_t \otimes \varepsilon_t \quad (61)$$

in the case of mimicking factor trading portfolios we have:

$$h_t^T = [1, Z_{kt}], \quad \varepsilon_t = Z_t - a - BZ_k, \quad \text{and} \quad \Theta^T = [a^T B^T]$$

where Z_t is the $(N \times 1)$ vector of excess returns for N portfolios (or assets) in time t . B is the $(N \times K)$ matrix of factor sensitivities, Z_k is the $(K \times 1)$ vector of factor portfolios excess returns in time t , a is a $(N \times 1)$ vector of intercepts, and ε_t is the $(N \times 1)$ disturbance in time t , and in the case of the macroeconomic variable factor the equation is:

$$h_t^T = [1, f_{kt}], \quad \varepsilon_t = R - a - Bf_{kt}, \quad \text{and} \quad \Theta^T = [a^T B^T]$$

In this equation system, R is an $(N \times 1)$ vector, of the N assets returns, a is the $(N \times 1)$ vector of intercepts, f is a $(K \times 1)$ vector of the k risk factors, B is the $(N \times k)$ matrix of betas or sensitivities slopes, and finally, e is the $(N \times 1)$ vector of disturbances. The rest of the procedure is straightforward and similar to the single factor tests. GMM tests do not rely on the normality assumptions and they accommodate the existence of heteroskedasticity and serial correlation, but they are asymptotically efficient.

e. Summary

In this section the econometrics for testing the multifactor pricing models has been reviewed. These models provide an attractive alternative to the single-factor CAPM. The evidence supporting multifactor pricing is mixed. Even multifactor models have difficulty explaining the size and BE/ME effect. However, Carhart (1997) adds a fourth-factor based on the “momentum” effect and improves explanatory power in the respective model. Generally, the multifactor models improve the cross-sectional descriptive power of the traditional CAPM.

V. OTHER RECENT APPROACHES.

New statistical approaches are being continuously developed and applied to the financial markets. In this section some recent applications are briefly recognized, but they are not utilized in the present research.

a. Bayesian Approach.

Several asset pricing models have been developed (i.e., CAPM, ICAPM, APT, and CCAPM) that attempt to explain the environment in which investment decisions are made. Another approach is data-based which assumes a functional form for the distribution of asset returns and estimates its parameters from times series of returns. This approach ignores the potential usefulness of asset pricing models. These two approaches reflect two views of investment decisions. Instead, it might be reasonable to assume that financial models are neither perfect or useless. Pastor (1999) proposes

an approach whereby financial models for decision making can be developed in a Bayesian framework. An asset pricing model could be used as a point of reference around which the investor can center his prior beliefs, data driven. Pastor argues that the relative importance of the sample evidence versus the model depends on the strength of the violations of the model in data relative to the strength of the prior beliefs in the model.

Bayesian estimation provides a convenient framework for incorporating prior information, or a learning process, with as much weight as the analyst feels it deserves. In Bayesian statistics, the parameter to be estimated is regarded as a random variable. All inference about it takes the form of probability assumptions and the goal is to describe the parameter in terms of a probability distribution. Any information that the researcher has about the parameters before observing the data is presented by a prior density. Probability statements that would be made about the coefficients after the data have been observed are based on the posterior density. This approach follows the Bayesian law where the posterior density is conditional to the prior density. The final coefficient estimates would be a weighted average of the classical statistics and an estimate based on prior information alone. High weight in the prior information corresponds to greater confidence on the ex ante sample. When the ex ante sample is a diffuse or improper prior density, the Bayesian coefficients collapse towards the classical statistics.

b. Genetic algorithms

Genetic algorithms belong to a class of machine learning algorithms that have been successfully used in a number of research areas. There is a growing interest in their use in financial markets, but so far there has been little formal analysis. Allen and Karjarlainen (1998) use genetic algorithms to find trading rules.

VI. CONCLUSION

In this chapter the tests for the CAPM have been reviewed. The multivariate test in its Wald and LR adjusted version overcomes the EIV problem that the classic two-pass test presents. However, multivariate tests have strong assumptions about the distribution of the returns, and empirical evidence supports deviations from this assumption.

Recently, GMM tests that accommodate for this deviation have been developed in the Wald and LR version. Nonetheless, in all the test versions the CAPM has been rejected. There is controversy about how this evidence should be interpreted. Several explanations have tried to explain the rejection. One line of thought is that one-factor does not capture the market risk, and additional factors are necessary.

Merton (1973) and Ross (1976), among others, developed the theoretical framework for multifactor models. Several researchers have used extensions to a multifactor model. This chapter shows the econometrics for estimating and testing multifactor-pricing models. Although these models provide an appealing alternative

to overcome the CAPM-related problems, the evidence supporting them is mixed, although the cross-sectional variance has been improved. These multifactor methods have several critics. MacKinlay (1995) argues that two serious dangers exist and occur when factors are chosen to fit the existing data without regard to economic theory. First, the model can fit the data because of data snooping and in this case will not be able to predict asset returns in the future. Second, the models may capture empirical regularities that are due to market inefficiency or investor irrationality and result in Sharpe ratios that are too high to be consistent with a reasonable model of market equilibrium. Otherwise, all the multifactor approaches are based on the returns covariance matrix. Daniel and Titman (1997) present evidence against these theories and argue that after the characteristic (e.g., the BE/ME or size) is controlled for, the beta does not possess explanatory power.

CHAPTER 5

ANALYSIS OF RESULTS

I. INTRODUCTION

Chapter 2 explains the basic theory behind the asset pricing models and Chapter 4 the methodologies used to test pricing models. In this chapter, the pricing theory and the econometric methods are linked to form a pricing model that explains the returns of the Mexican stock market. The methodology necessary to achieve the goal and objectives of this dissertation and to test the different hypotheses presented in Chapter 1 are developed along with the results obtained.

In section II, the data used to perform the proposed experiment and its main characteristics are described. Section III presents the methodology to perform a multifactor model that explains the Mexican stock market returns and the results of its application. This model is based on Carhart's (1997) model which includes market, size, BE/ME, and momentum factors plus the exchange rate risk factor. Section IV analyzes additional testing procedures to take into account the approach of foreign investors, the influence on the model of the December 1994 devaluation economic shock and the difference between an equally-weighted or value-weighted market index. Section V analyzes the dynamics among the factors. Due to the important participation of foreign investors in the Mexican stock market, an additional approach to test the exchange rate risk factor is presented in Section VI. In section VII, the

multifactor model will be tested against the characteristic model of Daniel and Titman (1997) because it is important to examine whether covariance or characteristics provide a better description of the expected returns. Concluding remarks are presented in the last section.

II. DATA

The base data used in this paper includes monthly closing prices and financial information from 1988 to 1998 (based on the end of the month). The data also contain the December 31 book equity, and the number of outstanding shares, monthly Mexican T-bill (Cetes), the U.S. T-bill, the monthly average peso/dollar exchange rate, and the JP Morgan Mexican Bond Index. Prices and financial data of the firms were supplied by the Mexican stock exchange (1987-1998), INFOSEL (1993-1998) and El Financiero (1988-1998). The measures are all in nominal returns. Cetes and the peso/dollar exchange rate data were provided by INEGI, and the JP Morgan Mexican Bond Index was extracted from Bloomberg.¹

During the 1988-1989 period, 330 firms traded in the Mexican stock exchange. However, some of the firms traded for short periods and experienced minimal trading volume. Between 1992 and 1993, several financial firms consolidated and reduced the number of issues. On average, the data base contains 112 firms, with a minimum

¹ I wish to thank all that helped me gather this data set. Special thanks to Martin Herrera.

of 82 and a maximum of 141 per month. All firms are included in order to avoid survivorship bias.

III. MULTIFACTOR PRICING MODELS

In this section the market is analyzed from the Mexican investor's viewpoint. This means that all the returns are in pesos and the risk free rate is the Cetes. In Section IV, the same model is analyzed from the perspective of the international investor, and returns are in U.S. dollars and the U.S. T-bill is the risk free rate.

Before trying a multifactor model, it is necessary to test the empirical form of the CAPM to see if it is rejected in the Mexican stock market:

$$R_{it} - R_{ft} = \alpha_i + \beta_i (R_{Mt} - R_{ft}) + e_{it} \quad (1)$$

In the above equation, as a market proxy, an equally-weighted index that includes all the stocks present in the market each month minus the risk free rate is used. As a proxy for the risk free rate, the 28-day Cetes is used. The dependent variable will be the excess returns on a ten equally-weighted portfolios. Earlier studies (see Chapter 4) about ten portfolios over 60 months bears sufficient for the tests. The portfolios are formed using the following procedures:

- Six are the Fama and French (1993) portfolios based on size and BE/ME ratio (BH, BM, BL, SH, SM and SL), where BH is the portfolio that contains the stocks

with the highest book value and largest capitalization, BM is the portfolio that contains the stocks with the highest book value and middle capitalization, and so forth.

-Two portfolios are based on the last calendar year's returns. The traded stocks were sorted into three categories: a high third, middle third and low third. One portfolio contains the stocks with the highest returns (MO1) and the second portfolio contains the stocks with the lowest returns (MO3).

-Two additional portfolios were assembled in a similar manner by dividing stocks into three categories high, middle and low. These portfolio classes are based on the ex ante beta loading between the stock returns and the percentage change of the peso/dollar exchange rate. The highest third is labeled EX1, the lowest third is labeled EX3.

Table 2 presents the monthly mean return and the standard of the portfolios that comprise the dependent variables. These portfolios are designed to stress the CAPM test. All the portfolios are equally-weighted by month and the weights are readjusted whenever a stock disappears. Table 3, Panel A shows the results of the ten time series for equation (1). The results are similar to the results found in the United States in that the intercept is different from zero and the t-statistic in absolute value is above two in eight of ten time series. Furthermore, the null hypothesis, $H_0: \alpha=0$, is rejected at the one percent level by several tests (see Table 3, Panel D). These results suggest the need to search for a more complex pricing model.

TABLE 2
Statistics of Portfolios Forming the Dependent Variable

Table 2 presents the mean monthly return and monthly standard deviation that comprise each of the ten portfolios that are used as dependent variables in the CAPM and multifactor tests. BH, BM, BL, SH, SM, and SL are portfolios sorted by size and BE/ME ratio, following the Fama and French (1993) methodology. MO1 and MO3 are the third with highest and lowest previous calendar year's return. EX1 and EX3 are the third with highest and lowest ex ante beta loading between individual and the peso/dollar exchange rate fluctuation (percentage change). These portfolios are monthly equally-weighted so the weights are readjusted whenever a fund disappears. The period is July 89 to December 98.

Dependent Variables	Mean Return	Standard Deviation
BH	1.31	8.96
BM	3.47	8.35
BL	4.81	8.09
SH	0.21	7.58
SM	2.34	6.84
SL	3.79	7.20
MO1	3.19	6.98
MO3	1.34	7.41
EX1	2.77	6.51
EX3	2.51	8.81

a. Size and BE/ME Factors

Fama and French (1992) show that different variables such as size, leverage, earnings-price rate (E/P), and book-equity to market-equity ratio (BE/ME) are correlated with stock returns. They suggested that size and BE/ME seem to absorb the apparent role of the other variables. However, Fama and French (1993) found that in time series regressions, size and BE/ME alone cannot explain the difference between stock returns and the T-bill returns. They used a market proxy to explain this difference. The market proxy is the same that is used in the CAPM test. For the size and BE/ME factors, the mimicking factor portfolio technique of Fama and

TABLE 3
CAPM and Multifactor Pricing Models, July 1987 to December 1998

Panel A presents $R_{it} - R_{ft} = \alpha_i + \beta_i(R_{M_t} - R_{ft}) + e_{it}$

$$R_{it} - R_{ft} = \alpha_i + \beta_{i1}(R_{M_t} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + e_{it}$$

Panel B $R_{it} - R_{ft} = \alpha_i + \beta_{i1}(R_{M_t} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}EX_t + e_{it}$

Panel C $R_{it} - R_{ft} = \alpha_i + \beta_{i1}(R_{M_t} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}EX_t + \beta_{i5}MO_t + e_{it}$

The dependent variables are the excess returns of the ten portfolios (BH, BM, BL, SH, SM, SL, MO1, MO3, EX1 and EX3) described in Table 2. Mkt is the equally-weighted market index minus the Cetes. SMB and HML are Fama and French's (1993) factor mimicking portfolios for size and BE/ME. MO is a factor mimicking portfolio for Jegadeesh and Titman (1993) momentum effect. EXR is a factor mimicking the peso/dollar exchange rate. Alpha is the intercept of the model. The t-statistics are in underlined italics. Panel D presents the W_α , LR_3 and G_w test and its p -value. A detailed explanation of these tests is in Chapter 4. The period is July 1989 to December 1998.

PANEL A

	CAPM			Three-Factor Model				
	α	Mkt	R2	α	Mkt	SMB	HML	R2
BH	-0.011 <i>-2.80</i>	1.180 <i>19.51</i>	0.77	0.001 <i>0.24</i>	1.009 <i>22.08</i>	-0.649 <i>-9.86</i>	0.518 <i>7.95</i>	0.89
BM	0.011 <i>3.33</i>	1.144 <i>24.07</i>	0.83	0.008 <i>2.37</i>	1.009 <i>24.36</i>	-0.474 <i>-7.95</i>	0.045 <i>0.76</i>	0.89
BL	0.024 <i>6.90</i>	1.063 <i>20.04</i>	0.78	0.008 <i>2.79</i>	0.928 <i>23.61</i>	-0.436 <i>-7.69</i>	-0.331 <i>-5.91</i>	0.90
SH	-0.020 <i>-3.81</i>	0.790 <i>9.79</i>	0.45	0.012 <i>2.98</i>	0.958 <i>18.83</i>	0.507 <i>6.93</i>	0.776 <i>10.70</i>	0.82
SM	0.001 <i>0.23</i>	0.772 <i>11.62</i>	0.54	0.001 <i>0.24</i>	0.950 <i>15.91</i>	0.640 <i>7.43</i>	-0.169 <i>-1.98</i>	0.69
SL	0.015 <i>4.58</i>	0.964 <i>20.17</i>	0.78	0.004 <i>1.18</i>	1.038 <i>23.28</i>	0.295 <i>4.59</i>	-0.375 <i>-5.91</i>	0.84
MO1	0.008 <i>3.88</i>	0.986 <i>30.14</i>	0.88	0.005 <i>1.79</i>	0.937 <i>27.96</i>	-0.163 <i>-3.37</i>	-0.063 <i>-1.33</i>	0.90
MO3	-0.010 <i>-3.34</i>	1.015 <i>22.18</i>	0.81	-0.005 <i>-1.35</i>	1.058 <i>21.80</i>	0.139 <i>2.00</i>	0.106 <i>1.54</i>	0.82
EX1	0.010 <i>2.84</i>	0.831 <i>15.36</i>	0.71	0.017 <i>3.62</i>	0.856 <i>14.59</i>	0.067 <i>0.81</i>	0.147 <i>1.81</i>	0.72
EX3	0.008 <i>1.89</i>	1.170 <i>19.31</i>	0.79	0.014 <i>2.67</i>	1.179 <i>17.79</i>	0.015 <i>0.16</i>	0.160 <i>1.74</i>	0.80

TABLE 3- continued

PANEL B
Four-Factor Model

	α	Mkt	SMB	HML	EXR	R2
BH	0.001 <u>0.23</u>	1.021 <u>18.90</u>	-0.610 <u>-8.57</u>	0.478 <u>6.70</u>	0.124 <u>1.43</u>	0.89
BM	0.006 <u>1.74</u>	0.974 <u>23.20</u>	-0.475 <u>-8.59</u>	0.012 <u>0.22</u>	0.228 <u>3.39</u>	0.93
BL	0.007 <u>2.18</u>	0.882 <u>20.02</u>	-0.452 <u>-7.78</u>	-0.329 <u>-5.66</u>	0.108 <u>1.53</u>	0.91
SH	0.010 <u>2.21</u>	0.884 <u>15.16</u>	0.476 <u>6.19</u>	0.764 <u>9.93</u>	0.185 <u>1.98</u>	0.83
SM	0.001 <u>0.11</u>	0.969 <u>13.82</u>	0.670 <u>7.25</u>	-0.174 <u>-1.89</u>	0.073 <u>0.65</u>	0.71
SL	0.003 <u>0.89</u>	1.023 <u>20.20</u>	0.318 <u>4.76</u>	-0.429 <u>-6.41</u>	0.201 <u>2.48</u>	0.86
MO1	0.005 <u>1.64</u>	0.915 <u>24.63</u>	-0.131 <u>-2.68</u>	-0.082 <u>-1.68</u>	0.110 <u>1.85</u>	0.91
MO3	-0.007 <u>-1.93</u>	1.065 <u>21.44</u>	0.083 <u>1.27</u>	0.097 <u>1.48</u>	0.017 <u>0.21</u>	0.87
EX1	0.010 <u>2.35</u>	0.763 <u>13.29</u>	0.031 <u>0.41</u>	0.072 <u>0.95</u>	0.409 <u>4.45</u>	0.76
EX3	0.004 <u>0.96</u>	1.039 <u>17.59</u>	-0.039 <u>-0.50</u>	0.047 <u>0.60</u>	0.619 <u>6.55</u>	0.86

TABLE 3- continued

PANEL C
Five-Factor Model

	α	Mkt	SMB	HML	EXR	MO	R2
BH	0.000	1.033	-0.592	0.492	0.116	0.081	0.89
	<u>-0.01</u>	<u>18.70</u>	<u>-8.11</u>	<u>6.78</u>	<u>1.34</u>	<u>1.05</u>	
BM	0.006	0.972	-0.477	0.011	0.229	-0.010	0.93
	<u>1.72</u>	<u>22.53</u>	<u>-8.35</u>	<u>0.19</u>	<u>3.38</u>	<u>-0.16</u>	
BL	0.007	0.891	-0.439	-0.318	0.102	0.060	0.91
	<u>1.92</u>	<u>19.76</u>	<u>-7.36</u>	<u>-5.37</u>	<u>1.44</u>	<u>0.95</u>	
SH	0.009	0.891	0.485	0.772	0.181	0.043	0.83
	<u>2.03</u>	<u>14.86</u>	<u>6.12</u>	<u>9.80</u>	<u>1.92</u>	<u>0.51</u>	
SM	0.000	0.973	0.675	-0.170	0.071	0.025	0.71
	<u>0.05</u>	<u>13.49</u>	<u>7.08</u>	<u>-1.79</u>	<u>0.63</u>	<u>0.24</u>	
SL	0.003	1.033	0.332	-0.417	0.195	0.064	0.86
	<u>0.67</u>	<u>19.90</u>	<u>4.83</u>	<u>-6.12</u>	<u>2.40</u>	<u>0.88</u>	
MO1	0.000	0.974	-0.046	-0.011	0.073	0.398	0.97
	<u>-0.06</u>	<u>40.87</u>	<u>-1.45</u>	<u>-0.35</u>	<u>1.94</u>	<u>11.88</u>	
MO3	0.000	0.974	-0.046	-0.011	0.073	-0.602	0.97
	<u>-0.06</u>	<u>40.87</u>	<u>-1.45</u>	<u>-0.35</u>	<u>1.94</u>	<u>-17.97</u>	
EX1	0.007	0.803	0.088	0.120	0.384	0.266	0.79
	<u>1.67</u>	<u>14.44</u>	<u>1.19</u>	<u>1.64</u>	<u>4.40</u>	<u>3.41</u>	
EX3	0.007	1.008	-0.084	0.010	0.638	-0.208	0.89
	<u>1.52</u>	<u>17.17</u>	<u>-1.08</u>	<u>0.13</u>	<u>6.92</u>	<u>-2.52</u>	

TABLE 3- continued

PANEL D
Multivariate Battery Tests of the CAPM and the Multifactor Models

	7/89- 12/98			
	CAPM	3-Factors	4-Factors	5-Factors
W_a	8.48	4.24	2.25	1.37
<i>p-value</i>	<u>0.00</u>	<u>0.00</u>	<u>0.02</u>	<u>0.21</u>
LR_3	71.06	35.23	22.94	14.25
<i>p-value</i>	<u>0.00</u>	<u>0.00</u>	<u>0.01</u>	<u>0.16</u>
G_w	187.96	38.45	24.88	17.15
<i>p-value</i>	<u>0.00</u>	<u>0.00</u>	<u>0.01</u>	<u>0.07</u>
	7/89- 12/93			
W_a	2.19	1.44	1.29	0.84
<i>p-value</i>	<u>0.03</u>	<u>0.18</u>	<u>0.25</u>	<u>0.59</u>
LR_3	18.22	13.16	8.62	8.09
<i>p-value</i>	<u>0.05</u>	<u>0.21</u>	<u>0.57</u>	<u>0.62</u>
G_w	65.45	17.23	11.54	9.08
<i>p-value</i>	<u>0.00</u>	<u>0.07</u>	<u>0.32</u>	<u>0.52</u>
	1/94- 12/98			
W_a	3.92	3.18	0.86	0.80
<i>p-value</i>	<u>0.00</u>	<u>0.00</u>	<u>0.57</u>	<u>0.63</u>
LR_3	48.11	40.05	16.13	11.21
<i>p-value</i>	<u>0.00</u>	<u>0.00</u>	<u>0.10</u>	<u>0.34</u>
G_w	74.32	41.11	18.45	9.08
<i>p-value</i>	<u>0.00</u>	<u>0.00</u>	<u>0.05</u>	<u>0.52</u>

French (1993) is used. The period to be analyzed is July 1989 to December 1998.

Data from 1988 is also necessary because portfolios need to be sorted based on information from the previous year.

All the common stocks in the Mexican stock exchange are sorted by size (ME=shares outstanding x share market price) and split into two groups, small and big (S and B). Then each group is sorted by BE/ME into three equal categories or

sub-groups (low L, medium M, high H). This sorting from July t to June $t+1$ uses the book equity information of December $t-1$. At this point the stocks represent six categories BL, BM, BH, SL, SM, and SH. The next step is to calculate the monthly equally-weighted returns of the six size-BE/ME based portfolios. This procedure isolates the characteristic change through time. Then, although the characteristic (size or BE/ME) in each individual firm could be time varying, characteristic-sorted portfolios remain constant due to the sorting process. The mimicking size factor portfolio is a combination of a long position in the small portfolios (SL+SM+SH)/3 and a short position in the big portfolios (BL+BM+BH)/3 and will be labeled SMB (small minus big). The mimicking BE/ME portfolio is a long position in the high (SH+BH)/2 portfolios and short position in the low (SL+BL)/2 portfolios. This is labeled the HML (high minus low) portfolio and is meant to mimic the risk factor in returns related to BE/ME. Using returns over treasury bills for the ten portfolios as a dependent variable, the following equation is estimated:

$$R_{it} - R_{ft} = \alpha_i + \beta_{i1}(R_{Mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + e_{it} \quad (2)$$

Equation (2) includes the size and BE/ME factors. Panel A of Table 3 shows the time series regression for each dependent variable. It can be perceived that the three-factor model improves the single-factor model. It is interesting to observe that not only in the size and BE/ME based portfolios (BH, BM, BL, SH, SM and SL) are

the HML and SMB factors significant, but the SMB factor also helps to explain both of the momentum portfolios (MO1 and MO3), and the HML factor has t-statistics close to two in the exchange rate portfolios (EX1 and EX3). The Wald test for the null hypothesis, $H_0: \alpha=0$, in the CAPM is 8.4 vs. 4.2 of the three-factor model, the adjusted R2 average of the ten regressions increases from 0.73 to 0.83, and the fact that 12 out of 20 of the beta loadings of the SMB and HML are significant suggest that the three-factors model is an improvement over the CAPM. However, it is important to remark that in both models the null hypothesis, $H_0: \alpha=0$, is rejected at one percent level (see Table 3, Panel D).

b. Exchange Rate Factor

In Chapter 2, Section V explains the importance of exchange rate fluctuation as a source of risk for international investors. The recent empirical research of Dumas and Solnik (1995), Choi and Rajan (1997), and Choi, Hikari, and Takezawa (1998) emphasize the importance of exchange risk as an additional factor.

The fluctuation of the peso/dollar exchange rate has been a source of risk for many firms in Mexico. The risk could be due to import or export transactions, debt in U.S. dollars, or other indirect causes. Fluctuations in the peso/dollar exchange rate affect firms in different ways depending on their position and extent of participation in international trade. However, there are other firms that do not participate in international markets or that are perfectly hedged and these firms would not be as

affected by the fluctuations of the peso/dollar exchange rate. These firms present low correlation with the exchange rate. If investors are aware of exchange rate risk, a special premium should be demanded from the companies that are affected by this risk factor.

In order to determine if a premium exists and if the factor improves the three-factor model, a zero cost portfolio, mimicking the fluctuation of the peso/dollar exchange rate (EXR), is formed. For each December from 1990 to 1997, the ex ante beta loading between the individual stock returns and the peso/dollar exchange rate fluctuation (percentage change) is calculated. Three groups are formed; EX1 has the highest positive beta loading, EX3 has the highest negative beta loading, and EX2 contains the firms with the lowest (positive and negative) loadings. Investors may consider the groups EX1 and EX3 as the riskiest groups and EX2 as the safest group, measured against exchange rate risk. The mimicking peso/dollar exchange rate factor is formed with a long position in the riskiest groups $(EX1+EX3)/2$ and a short position in the safest group (EX2). Monthly equally-weighted returns are calculated from January 1991 through December 1998 with annual portfolio rebalance.

Formally, the model is:

$$R_{it} - R_{ft} = \alpha_i + \beta_{i1}(R_{Mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}EX_t \quad (3)$$

Panel B of Table 3 shows the results of the regression. It is important to note that in six of the ten regressions the t-statistic of the EX coefficient is close to or larger than two, and in four, the magnitude of the coefficient is bigger than the coefficient of the HML factor. The Wald test for the null hypothesis, $H_0: \alpha=0$, for this four-factor model is 2.3 vs. 4.2 for the three-factor model. This is an improvement, and the four-factor model is not rejected at the one percent level in the total period, and not rejected at the five percent level in four out of six tests when the five year subperiods are analyzed. The evidence suggests that the peso/dollar exchange rate is a factor that helps to explain the stock returns in the Mexican stock market. So far, it seems that this is the first application of the mimicking factor portfolio technique to implementing an exchange rate risk factor. The traditional approach that has been used is the macroeconomic variables as factors where the exchange rate is used directly as factor. This approach is used in Section VI to corroborate the results found with the mimicking technique.

c. Momentum Factor

Jegadeesh and Titman (1993) show that a correlation of present returns with past returns exists. Carhart (1997) added a momentum factor (MO) to the Fama and French (1993) model, improving the explanatory power of the model.

In addition to the previously presented four-factors model, the MO factor will be added and tested using:

$$R_{it} - R_{ft} = \alpha_i + \beta_{i1}(R_{Mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}EX_t + \beta_{i5}MO_t \quad (4)$$

For each December from 1988 to 1997, the stocks are sorted by annual returns and three groups are formed. The momentum mimicking portfolio (MO), is constructed using a long position in the equally weighted average of firms falling in the highest 33 percent (winners) and a short position in the equally weighted average of firms falling in the lowest 33 percent (losers). The portfolios are recalculated annually.

Panel C of Table 3 presents the results of the ten regressions using the five-factors. The MO1 and MO3 portfolios are improved with the presence of the MO and the t-statistics of MO in both cases are quite strong. The MO factor helps to explain the EX1 and EX3 portfolios. Most important is that in the five-factor model the null hypothesis, $H_0: \alpha=0$, is not rejected at the ten percent level in the Wald test. This suggests that the five-factor model is an improvement over the other models.

d. The Battery of Tests

Chapter 4 developed the different methods to apply multivariate tests to a pricing model. There is no single perfect test, and each multivariate method possesses advantages and disadvantages. Each has test strengths and test weaknesses. The Wald Adjusted Test (W_a) has an exact finite distribution but relies on a normal i.i.d. assumption. The Likelihood Adjusted Test (LR_3) also relies on a normal i.i.d.

assumption, but has more power because it compares the restricted model with the unrestricted model. The Wald GMM Test (G_w) does not rely on normality assumptions, but is asymptotically efficient. Panel D of Table 3 presents test results of these tests for the CAPM, and the three, four and five-factor models. The time periods tested are the total period spanning July 1989 to December 1998 and the two five year subperiods.

The CAPM is rejected at the one percent statistical significance level with all the tests in the complete period. The three-factor model is rejected for the total period due to the subperiod 94-98. The four-factor model is not rejected at the one percent level but rejected at five percent level. The five-factor model is not rejected at the five percent level in all the tests and all the time periods.

The fact that the CAPM is universally rejected and the five-factor model not rejected is consistent with the hypothesis that the five-factor model is an improvement over the CAPM independent of its theoretical explanation. The addition of each factor improves the multivariate tests, and the adjusted R²'s. Table 4, Panel B presents individual t-statistics for each factor, the null hypothesis, $H_0: \lambda=0$, (where λ is the factor premium) is rejected at 1 percent level for the SMB, HML and MO factors, and at two percent for the EXR factor. This is consistent with the hypothesis that each factor is significant.

e. Market Index

In Table 4, Panel A presents the mean monthly return expressed as a percentage for each year, data for five year subperiods, and for the total period. Panel B presents the standard deviation in percentages, and Panel C the cross-correlation among the factors. An equally-weighted market index (EWMI) is computed using all the stocks that were traded each month for the whole period. A value weighted index (VWMI) with monthly rebalance to avoid survivorship bias is developed. The correlation between the EWMI and the VWMI is 0.89. In the United States, the EWMI has a mean return higher than VWMI due to the major weight that the EWMI places on small firms which on average have higher return. In Mexico, this relationship is inverted. The VWMI earn larger returns than the EWMI due to the negative size effect (big companies have earned returns superior to small firms in Mexico during the July 1989 to December 1998 period). The years from 89-93 represent a bullish period in the Mexican stock exchange. Both indices exceeded the Cetes. This relationship is reversed during the bearish period (94-98), where on average, the market was lower than Cetes².

² The mean monthly returns in percentage for the IPC and Cetes respectively was 4.58 and 1.90 for 89-93 period, and 1.54 and 2.01 for 94-98 period.

f. Size, BE/ME, Momentum and Exchange Premiums

The premium of the size and BE/ME mimicking factor (SMB and HML) is negative during all the years for HML and during nine years for the SMB factor. A possible explanation for the negative premium could be the Mexican context of the last years. It began with the globalization economic policies of President Miguel de la Madrid. The General Agreement on Tariffs and Trade (GATT) signed by Mexico in 1986 and the North America Free Trade Agreement (NAFTA) signed in 1993 opened opportunities for large firms to compete in a wide world arena. However, the medium and small firms were at a disadvantage compared to their international competitors. The large firms yield higher returns than small firms in the 89-98 period because large firms had more growth than the small firms and this created a differential in returns between large and small firms.

The threat of an open trade war could cause a similar perception with the BE/ME ratio. Investors have preferred the low risk stocks (low BE/ME) avoiding high risk firms (high BE/ME) provoking a negative HML premium during the period. The statistical significance of the strong negative premium for the SMB and HML factor deserves future research. Carhart (1997) reports a mean monthly excess return for July 1963 to December 1993 of 0.29 and 0.46 for the SMB and HML factors respectively and standard deviations of 2.89 and 2.59 percent.

Although in Mexico the standard deviation is almost double, the factor

TABLE 4
Mean Monthly Returns, Standard Deviation and Correlation Among Factors
and Market Proxies

RF is the one-month Mexican T-bill (CETES). VW-RF is the value weight market index minus the RF. EW-RF is the equally-weighted market index minus the RF. SMB and HML are Fama and French's (1993) factor mimicking portfolios for size and BE/ME. MO is a factor mimicking portfolio for Jegadeesh and Titman (1993) momentum effect. EXR is a factor mimicking the peso/dollar exchange rate. Panel A presents the monthly mean returns. Panel B the monthly standard deviation and Panel C the cross correlation among them.

PANEL A
Monthly Mean Returns

	RF	EW-RF	VW-RF	SMB	HML	MO	EXR
1989	3.13	3.54	5.41	-0.15	-0.04	-0.05	
1990	2.51	2.70	4.12	-0.61	-4.47	0.86	
1991	1.48	4.64	7.31	-0.56	-5.99	3.69	0.46
1992	1.22	1.47	2.78	-1.04	-4.11	-0.20	1.58
1993	1.17	2.63	2.97	-2.70	-2.02	1.25	0.95
1994	1.09	0.10	-0.85	2.59	-2.01	-1.49	0.63
1995	3.33	-4.10	-0.71	-3.35	-6.45	5.25	0.88
1996	2.29	-0.74	-0.11	-1.78	-2.75	2.16	-0.66
1997	1.51	1.64	3.03	-0.57	-2.61	3.25	2.40
1998	1.84	-5.68	-2.04	-2.22	-3.21	3.49	-0.24
89-93	1.90	3.00	4.52	-1.11	-3.69	1.11	1.00
94-98	2.01	-1.75	-0.14	-1.06	-3.41	2.53	0.60
89-98	1.96	0.62	2.19	-1.08	-3.54	1.82	0.75

TABLE 4-continued

PANEL B
Monthly Standard Deviation

	RF	EW-RF	VW-RF	SMB	HML	MO	EXR
1989	0.44	6.62	7.01	3.05	2.71	4.51	
1990	0.49	5.12	10.47	3.83	2.61	8.29	
1991	0.19	3.83	8.87	5.75	5.30	2.23	2.90
1992	0.17	6.92	10.03	6.75	4.32	3.31	4.23
1993	0.13	5.83	8.06	3.50	3.98	2.56	3.61
1994	0.19	4.89	5.92	3.69	4.05	3.97	3.65
1995	0.76	9.29	10.75	5.72	4.42	4.28	5.21
1996	0.40	3.41	4.98	2.76	4.52	3.35	3.11
1997	0.11	5.71	7.33	3.47	4.78	4.63	4.58
1998	0.55	7.37	9.66	6.06	4.86	5.32	4.09
89-93	0.85	5.67	8.83	4.86	4.31	4.77	3.55
94-98	0.89	6.81	7.94	4.83	4.66	4.78	4.19
89-98	0.87	6.68	8.69	4.82	4.48	4.81	3.94
Sharpe Ratio	2.25	.093	0.252	.224	.790	.378	.190
t-statistic		0.99	2.67	2.39	-8.40	-4.02	2.03
<i>p-value</i>		<u>0.16</u>	<u>0.00</u>	<u>0.01</u>	<u>-0.00</u>	<u>-0.00</u>	<u>0.02</u>

PANEL C
Correlation Among the Factors

	VW-RF	EW-RF	SMB	HML	MO	EXR
VW-RF	1					
EW-RF	0.89	1				
SMB	-0.62	-0.40	1			
HML	-0.17	-0.04	0.29	1		
MO	0.14	-0.04	-0.28	-0.24	1	
EXR	0.26	0.33	0.01	0.23	-0.04	1

premium is 3.7 times for the SMB and 7.7 times in the HML factor. The results in Table 4 suggest that the size and BE/ME effect are stronger than in the U.S., independent of the theoretical interpretation behind it. Carhart's study shows that momentum is the factor with the larger premium of 0.82 percent. In Mexico, 89-98 period, the MO factor premium is 1.82 percent more, than double the U.S., and the standard deviation is only 1.4 times larger in Mexico. Assuming U.S. mutual funds are greater momentum investors, this factor may come from the U.S. foreign investment influence. The one year momentum has been stronger in the second period 1994-1998, but positive in both periods, and it has been positive in seven out of ten years. All over, this evidence suggests the presence of a momentum pattern in the Mexican stock exchange. It is important to remark that the t-statistic for each factor premium is significant (see Table 4, Panel B).

The results of the mimicking factor of the peso/dollar exchange rate fluctuation are of special interest for the globalization process that Mexico has entered in the last decade. The results in Table 4, Panel A show that in the 89-98 period, the EXR factor had a average monthly return of 0.75 percent per month, (over the 0.62 of the EWMI). The evidence is consistent with the hypothesis that investors perceive and demand for an exchange rate risk premium.

Comparing the Sharpe ratios (excess mean return/standard deviation) for the total period, the inverse of the HML (taking long positions in the low BE/ME and short in high firms) represents the best investment with a ratio of 0.79. MO is second with 0.38, the inverse of SMB is 0.224, the EXR is 0.19, and the EWMI is 0.093.

Carhart (1997) found Sharpe's ratios of 0.10, 0.10, 0.18, and 0.23 for the market, size, BE/ME, and momentum factors respectively.

Table 4, Panel C shows the correlation among all the factors. The VWMI has a strong negative correlation with the SMB factor (-0.62), but the EWMI has a -0.40 correlation with the same factor. The correlation between the EWMI and VWMI is 0.89. The rest of the correlations are below 0.33 in absolute value. In order to avoid the high correlation of the VWMI with the SMB factor, the EWMI is used in the regressions as market proxy, but in Section IV, the five-factor model is tested using the VWMI instead the EWMI to analyze the differences.

IV. ADDITIONAL TESTING PROCEDURES

The results so far presented could be affected by some methodological changes. If the 35 percent of foreign investors in the Mexican stock market think in terms of dollars, then former results could change if the CAPM and multifactor models are analyzed using dollar returns and the U.S. T-bill. Another event that could affect the results is the December 1994 devaluation economic shock. Finally, it must be determined if there are significant differences using VWMI instead of EWMI. This section address these three issues.

a. Foreign Investors Viewpoint

As mentioned in Chapter 3, the Mexican market is increasing in complexity and internalization. Trading is electronic and foreign investors have open access to the

Mexican stock market. Merrill Lynch, Goldman Sachs, and Bankers Trust are shareholders in the Mexican exchange and 35 percent of the issued stocks are owned by foreign investor's. These facts make it important to analyze the market from the foreign investors viewpoint using returns in dollars and the U.S. T-bill as a risk free rate. Table 5 and 6 present the CAPM and the three, four and five-factor models evaluated in dollars and with the U.S. T-bill as a reference risk free rate. Table 5 contains the statistics of the dependent variable, the market index and Mexican and the U.S. T-bill for the total period. In Table 6, the regression of all the models and W_a test are presented. The conclusions are similar to those achieved in the previous section for the models when using the Mexican T-bill and returns in pesos. During the total period, the null hypothesis, $H_0: \alpha=0$, at the one percent level, is rejected for the CAPM and not rejected for the five-factor model at the ten percent level. The factor beta-loadings, adjusted R2's are practically similar in the dollar and the peso cases. This is consistent with the hypothesis that the Mexican stock market is partially segmented and as Adler and Dumas (1983) suggest, exchange rate fluctuation is a source of risk and should be taken into account in the pricing models. The results are also consistent with the hypothesis that international investors play an important role in the Mexican stock market.

TABLE 5
Foreign Investor Viewpoint.
Statistics of Portfolios Forming the Dependent Variable, the Market Proxy and
the Risk Free Rate.

Panel A presents the mean monthly return in dollars, and monthly standard deviation of the ten portfolios that are used as dependent variables in the CAPM and multifactorial tests. BH, BM, BL, SH, SM, and SL are portfolios sorted by size and BE/ME ratio, following the Fama and French (1993) methodology. MO1 and MO3 are the third with highest and lowest previous calendar year's return. EX1 and EX3 are the third with highest and lowest ex ante beta loading between individual stocks and the peso/dollar exchange rate fluctuation. The market proxy, and the Mexican and U.S. T-bill returns in dollars are presented. These portfolios are monthly equally-weighted so the weights are readjusted whenever a firm disappears. The period is July 89 to December 98. Panel B presents the correlation among the Mexican index and the Mexican and U.S. T-bills.

PANEL A

	Mean Return	Standard Deviation
BH	-0.2	9.5
BM	1.90	9.0
BL	3.30	9.1
SH	-1.30	8.4
SM	0.80	8.0
SL	2.20	7.9
MO1	1.60	7.8
MO3	-0.20	8.1
EX1	1.50	7.7
EX3	1.30	9.7
Market	0.82	7.4
Mex. T-bill	0.38	4.1
U.S. T-bill	0.40	0.001

PANEL B

	<i>Mkt</i>	<i>Mex. T-bill</i>	<i>U.S. T-bill</i>
Mkt	1		
Mex. T-bill	0.46	1	
U.S. T-bill	0.02	-0.06	1

TABLE 6
Foreign Investor View point.
CAPM and Multifactor Pricing Models, July 1989 to December 1998

Panel A presents $R_{it} - R_{ft} = \alpha_i + \beta_i(R_{M_t} - R_{ft}) + e_{it}$

$$R_{it} - R_{ft} = \alpha_i + \beta_{i1}(R_{M_t} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + e_{it}$$

Panel B $R_{it} - R_{ft} = \alpha_i + \beta_{i1}(R_{M_t} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}EX_t + e_{it}$

Panel C $R_{it} - R_{ft} = \alpha_i + \beta_{i1}(R_{M_t} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}EX_t + \beta_{i5}MO_t + e_{it}$

The dependent variables are the returns in dollars over the U.S. T-bill of the ten portfolios (BH, BM, BL, SH, SM, SL, MO1, MO3, EX1 and EX3) described in Table 5. Mkt is the return in dollars of the EWMI minus the U.S. T-bill. SMB and HML are factor mimicking portfolios for size and BE/ME. MO is a factor mimicking portfolio for momentum effect. EXR is a factor mimicking the peso/dollar exchange rate. Alpha is the intercept of the model. The t-statistics are in underlined italics. Panel D presents the W_a test and its p -value for the whole period, and the five year subperiods.

PANEL A

	CAPM			Three-Factor Model				
	α	Mkt	R2	α	Mkt	SMB	HML	R2
BH	-0.011	1.138	0.79	0.001	1.010	-0.643	0.514	0.90
	<u>-2.70</u>	<u>20.86</u>		<u>0.25</u>	<u>25.13</u>	<u>-10.00</u>	<u>7.96</u>	
BM	0.011	1.123	0.86	0.008	1.020	-0.463	0.046	0.91
	<u>3.38</u>	<u>26.82</u>		<u>2.40</u>	<u>28.57</u>	<u>-8.02</u>	<u>0.79</u>	
BL	0.024	1.120	0.84	0.008	1.011	-0.382	-0.339	0.92
	<u>7.069</u>	<u>24.368</u>		<u>2.73</u>	<u>29.00</u>	<u>-6.84</u>	<u>-6.04</u>	
SH	-0.020	0.835	0.54	0.012	1.001	0.527	0.764	0.85
	<u>-3.79</u>	<u>11.58</u>		<u>3.03</u>	<u>22.53</u>	<u>7.41</u>	<u>10.70</u>	
SM	0.001	0.860	0.64	0.001	1.01	0.669	-0.173	0.76
	<u>0.18</u>	<u>14.17</u>		<u>0.28</u>	<u>19.29</u>	<u>7.97</u>	<u>-2.05</u>	
SL	0.014	0.971	0.82	0.004	1.020	0.281	-0.369	0.86
	<u>4.53</u>	<u>22.88</u>		<u>1.17</u>	<u>26.10</u>	<u>4.48</u>	<u>-5.86</u>	
MO1	0.008	1.008	0.92	0.004	0.971	-0.139	-0.069	0.92
	<u>3.88</u>	<u>34.90</u>		<u>1.72</u>	<u>32.92</u>	<u>-2.96</u>	<u>-1.46</u>	
MO3	-0.010	0.998	0.84	-0.004	1.033	0.119	0.112	0.85
	<u>-3.32</u>	<u>24.67</u>		<u>-1.30</u>	<u>24.35</u>	<u>1.76</u>	<u>1.64</u>	
EX1	0.010	0.893	0.77	0.017	0.925	0.102	0.138	0.78
	<u>2.82</u>	<u>18.00</u>		<u>3.62</u>	<u>17.43</u>	<u>1.23</u>	<u>1.67</u>	
EX3	0.007	1.177	0.84	0.014	1.189	0.028	0.158	0.84
	<u>1.89</u>	<u>22.16</u>		<u>2.71</u>	<u>20.71</u>	<u>0.31</u>	<u>1.76</u>	

TABLE 6- continued

PANEL B
Four-Factor Model

	α	Mkt	SMB	HML	EXR	R2
BH	0.001	1.019	-0.607	0.476	0.127	0.91
	<u>0.23</u>	<u>21.53</u>	<u>-8.67</u>	<u>6.70</u>	<u>1.49</u>	
BM	0.006	0.989	-0.462	0.013	0.220	0.94
	<u>1.74</u>	<u>23.20</u>	<u>-8.59</u>	<u>0.22</u>	<u>3.39</u>	
BL	0.008	0.977	-0.393	-0.328	0.057	0.92
	<u>2.44</u>	<u>24.64</u>	<u>-6.70</u>	<u>-5.52</u>	<u>0.79</u>	
SH	0.010	0.948	0.505	0.758	0.149	0.86
	<u>2.44</u>	<u>18.53</u>	<u>6.66</u>	<u>9.85</u>	<u>1.61</u>	
SM	0.001	1.016	0.693	-0.175	0.045	0.77
	<u>0.22</u>	<u>16.58</u>	<u>7.53</u>	<u>-1.90</u>	<u>0.410</u>	
SL	0.003	1.017	0.311	-0.425	0.203	0.88
	<u>0.83</u>	<u>23.02</u>	<u>4.76</u>	<u>-6.41</u>	<u>2.55</u>	
MO1	0.005	0.965	-0.101	-0.082	0.085	0.93
	<u>1.81</u>	<u>29.19</u>	<u>-2.07</u>	<u>-1.65</u>	<u>1.41</u>	
MO3	-0.007	1.019	0.055	0.097	0.038	0.88
	<u>-2.07</u>	<u>23.43</u>	<u>0.852</u>	<u>1.48</u>	<u>0.48</u>	
EX1	0.011	0.856	0.0764	0.070	0.362	0.81
	<u>2.48</u>	<u>16.22</u>	<u>0.97</u>	<u>0.88</u>	<u>3.80</u>	
EX3	0.004	1.077	-0.015	0.047	0.592	0.89
	<u>1.089</u>	<u>21.128</u>	<u>-0.19</u>	<u>0.61</u>	<u>6.42</u>	

TABLE 6- continued

PANEL C
Five-Factor Model

	α	Mkt	SMB	HML	EXR	MO	R2
BH	0.000	1.022	-0.596	0.488	0.1248	0.069	0.91
	<u>-0.01</u>	<u>21.51</u>	<u>-8.37</u>	<u>6.74</u>	<u>1.45</u>	<u>0.91</u>	
BM	0.006	0.989	-0.463	0.011	0.220	-0.006	0.94
	<u>1.75</u>	<u>26.76</u>	<u>-8.37</u>	<u>0.210</u>	<u>3.31</u>	<u>-0.10</u>	
BL	0.007	0.981	-0.379	-0.314	0.054	0.084	0.92
	<u>2.07</u>	<u>24.77</u>	<u>-6.40</u>	<u>-5.19</u>	<u>0.75</u>	<u>1.32</u>	
SH	0.009	0.952	0.515	0.767	0.146	0.065	0.85
	<u>2.19</u>	<u>18.50</u>	<u>6.68</u>	<u>9.81</u>	<u>1.57</u>	<u>0.79</u>	
SM	0.000	1.017	0.698	-0.168	0.044	0.035	0.77
	<u>0.13</u>	<u>16.49</u>	<u>7.55</u>	<u>-1.79</u>	<u>0.39</u>	<u>0.36</u>	
SL	0.002	1.019	0.320	-0.415	0.201	0.058	0.86
	<u>0.61</u>	<u>22.97</u>	<u>4.82</u>	<u>-6.13</u>	<u>2.52</u>	<u>0.82</u>	
MO1	0.000	0.986	-0.037	-0.011	0.069	0.398	0.97
	<u>0.00</u>	<u>47.87</u>	<u>-1.21</u>	<u>-0.34</u>	<u>1.87</u>	<u>12.08</u>	
MO3	0.000	0.988	-0.040	-0.009	0.060	-0.587	0.97
	<u>-0.06</u>	<u>47.95</u>	<u>-1.28</u>	<u>-0.28</u>	<u>1.62</u>	<u>-17.83</u>	
EX1	0.007	0.872	0.126	0.125	0.350	0.307	0.84
	<u>1.68</u>	<u>17.71</u>	<u>1.71</u>	<u>1.67</u>	<u>3.95</u>	<u>3.91</u>	
EX3	0.007	1.067	-0.046	0.011	0.600	-0.197	0.90
	<u>1.67</u>	<u>21.43</u>	<u>-0.62</u>	<u>0.15</u>	<u>6.68</u>	<u>-2.48</u>	

TABLE 6- continued

PANEL B
 W_a test

	CAPM		
07/89-12/98	07/89-12/93	01/94-12/98	
12.523	2.168	8.037	
<u>0.00</u>	<u>0.07</u>	<u>0.00</u>	
	3-Factor Model		
4.244	0.874	3.392	
<u>0.00</u>	<u>0.57</u>	<u>0.00</u>	
	4-Factor Model		
2.644	0.685	1.701	
<u>0.01</u>	<u>0.73</u>	<u>0.11</u>	
	5-Factor Model		
1.535	0.602	1.061	
<u>0.14</u>	<u>0.79</u>	<u>0.41</u>	

b. The December 1994 Devaluation Economic Shock

The Mexican economy suffered a disastrous economic shock in December 1994 when the peso was devalued. The devaluation was followed by high inflation, a decrease in GDP and high unemployment. A test was conducted eliminating the adjustment period (December 1994 through September 1995) to see whether the results so far presented are induced by this devaluation economic shock. Table 7 presents the five-factor model regression for the data period but eliminates the December 1994 to September 1995 data. The results suggest that the explanatory power (the adjusted R²'s, beta-loadings, and intercepts) of the model are not substantially affected.

TABLE 7
Five-Factor Model With Eliminating December 1994 Devaluation
Economic Shock.

Table 7 presents:

$$R_{it} - R_{ft} = \alpha_i + \beta_{i1}(R_{Mkt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}EX_t + \beta_{i5}MO_t + e_{it}$$

The dependent variables are the returns in dollars over the U.S. T-bill of the ten portfolios (BH, BM, BL, SH, SM, SL, MO1, MO3, EX1 and EX3) described in Table 5. Mkt is the return in dollars of the equally-weighted market index minus the U.S. T-bill. SMB and HML are Fama and French's (1993) factor mimicking portfolios for size and BE/ME. MO is a factor mimicking portfolio for Jegadeesh and Titman (1993) momentum effect. EXR is a factor mimicking the peso/dollar exchange rate. Alpha is the intercept of the model. The t-statistics are in underlined italics. The period is July 1989 to December 1998 but the months from December 1994 through September 1995 are eliminated from the sample.

Five-Factor Model							
	α	Mkt	SMB	HML	EXR	MO	R2
BH	0.002 <i><u>0.64</u></i>	1.003 <i><u>22.23</u></i>	-0.557 <i><u>-8.02</u></i>	0.509 <i><u>7.27</u></i>	0.023 <i><u>0.29</u></i>	0.099 <i><u>1.29</u></i>	0.91
BM	0.004 <i><u>1.54</u></i>	0.983 <i><u>26.42</u></i>	-0.439 <i><u>-7.68</u></i>	0.013 <i><u>0.22</u></i>	0.248 <i><u>3.69</u></i>	0.030 <i><u>0.47</u></i>	0.94
BL	0.007 <i><u>2.15</u></i>	1.011 <i><u>24.89</u></i>	-0.379 <i><u>-6.07</u></i>	-0.277 <i><u>-4.40</u></i>	0.069 <i><u>0.94</u></i>	0.034 <i><u>0.50</u></i>	0.92
SH	0.009 <i><u>2.27</u></i>	0.993 <i><u>19.50</u></i>	0.553 <i><u>7.05</u></i>	0.815 <i><u>10.32</u></i>	0.221 <i><u>2.41</u></i>	0.017 <i><u>0.20</u></i>	0.88
SM	0.000 <i><u>0.03</u></i>	0.984 <i><u>15.36</u></i>	0.643 <i><u>6.52</u></i>	-0.195 <i><u>-1.96</u></i>	-0.045 <i><u>-0.39</u></i>	0.075 <i><u>0.69</u></i>	0.75
SL	0.004 <i><u>1.25</u></i>	1.016 <i><u>22.98</u></i>	0.396 <i><u>5.83</u></i>	-0.378 <i><u>-5.51</u></i>	0.157 <i><u>1.98</u></i>	0.083 <i><u>1.11</u></i>	0.88
MO1	-0.002 <i><u>-0.18</u></i>	1.008 <i><u>53.11</u></i>	-0.063 <i><u>-2.16</u></i>	-0.021 <i><u>-0.73</u></i>	0.106 <i><u>3.10</u></i>	0.328 <i><u>10.19</u></i>	0.98
MO3	-0.004 <i><u>-0.25</u></i>	1.008 <i><u>52.21</u></i>	-0.065 <i><u>-2.20</u></i>	-0.019 <i><u>-0.64</u></i>	0.096 <i><u>2.76</u></i>	-0.653 <i><u>-19.88</u></i>	0.97
EX1	0.009 <i><u>2.36</u></i>	0.932 <i><u>20.59</u></i>	0.112 <i><u>1.60</u></i>	0.143 <i><u>2.03</u></i>	0.419 <i><u>5.14</u></i>	0.181 <i><u>2.35</u></i>	0.88
EX3	0.005 <i><u>1.27</u></i>	1.034 <i><u>20.40</u></i>	-0.027 <i><u>-0.35</u></i>	0.030 <i><u>0.39</u></i>	0.539 <i><u>5.90</u></i>	-0.139 <i><u>-1.62</u></i>	0.88

Note: the W_a test of the null hypothesis, $H_0: \alpha=0$, is 1.814 (*p-value .07*)

This means that the five-factor model coefficients are robust to the inclusion or not of the December 1994 devaluation economic shock.

c. The Model with the VWMI or EWMI

The previous section explains why the EWMI is selected instead of the VWMI. However, it is of interest to see what happens if in the five-factor model, the VWMI is used instead of the EWMI. Table 8 shows the results of the regression of the five-factor model in dollars, the U.S. T-bill, and the VWMI. The SMB factor lost statistical significance in one regression but acquired significance in the other four regressions. The other factors remain practically identical. This distortion of the SMB factor is due to its high correlation with the VWMI and the correlation distorts the meaning of the beta-loadings of the correlated factors. This is part of the justification for the use of the EWMI. However, the conclusions with both indices are consistent and the five-factor model is not rejected. Actually, the W_a test of the null hypothesis, $H_0: \alpha=0$, is smaller than in the former multifactor models already presented in this chapter.

d. Conclusion

The five-factor model developed for the July 1989 to December 1998 period of the Mexican stock market is not rejected by a battery of Wald, LR and GMM tests. It is

TABLE 8
The Five-Factor Model with the Value-Weighted Market Index.

Table 8 presents $R_{it} - R_{ft} = \alpha_i + \beta_{i1}(R_{Mkt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}EX_t + \beta_{i5}MO_t$
 Where the dependent variables are the returns in dollars over the U.S. T-bill of the ten portfolios (BH, BM, BL, SH, SM, SL, MO1, MO3, EX1 and EX3) described in Table 5. Mkt is the return in dollars of the VWMI minus the U.S. T-bill. SMB and HML are Fama and French's (1993) factor mimicking portfolios for size and BE/ME. MO is a factor mimicking portfolio for Jegadeesh and Titman (1993) momentum effect. EXR is a factor mimicking the peso/dollar exchange rate. Alpha is the intercept of the model. The t-statistics are in underlined italics. The period is July 1989 to December 1998.

Five-Factor Model							
	α	Mkt	SMB	HML	EXR	MO	R2
BH	-0.004 <i><u>-0.72</u></i>	0.856 <i><u>13.33</u></i>	-0.282 <i><u>-2.41</u></i>	0.569 <i><u>5.45</u></i>	0.196 <i><u>1.59</u></i>	-0.034 <i><u>-0.31</u></i>	0.81
BM	0.001 <i><u>0.31</u></i>	0.846 <i><u>15.78</u></i>	-0.141 <i><u>-1.44</u></i>	0.092 <i><u>1.06</u></i>	0.277 <i><u>2.70</u></i>	-0.105 <i><u>-1.15</u></i>	0.85
BL	0.003 <i><u>0.90</u></i>	0.905 <i><u>21.65</u></i>	0.013 <i><u>1.17</u></i>	-0.224 <i><u>-3.30</u></i>	0.067 <i><u>0.84</u></i>	-0.012 <i><u>-0.18</u></i>	0.90
SH	0.006 <i><u>1.28</u></i>	0.875 <i><u>16.75</u></i>	0.893 <i><u>9.38</u></i>	0.855 <i><u>10.06</u></i>	0.161 <i><u>1.61</u></i>	-0.028 <i><u>-0.31</u></i>	0.83
SM	-0.000 <i><u>-0.53</u></i>	0.878 <i><u>12.47</u></i>	1.039 <i><u>8.09</u></i>	-0.084 <i><u>-0.736</u></i>	0.097 <i><u>0.72</u></i>	-0.066 <i><u>-0.56</u></i>	0.65
SL	-0.002 <i><u>-0.34</u></i>	0.085 <i><u>13.58</u></i>	0.629 <i><u>5.51</u></i>	-0.335 <i><u>-3.29</u></i>	0.275 <i><u>2.29</u></i>	-0.045 <i><u>-0.42</u></i>	0.88
MO1	-0.004 <i><u>-0.99</u></i>	0.847 <i><u>19.15</u></i>	0.288 <i><u>3.57</u></i>	0.070 <i><u>0.97</u></i>	0.124 <i><u>1.47</u></i>	0.299 <i><u>3.98</u></i>	0.98
MO3	-0.004 <i><u>-1.02</u></i>	0.848 <i><u>19.11</u></i>	0.286 <i><u>3.54</u></i>	0.072 <i><u>1.00</u></i>	0.115 <i><u>1.35</u></i>	-0.687 <i><u>-9.13</u></i>	0.97
EX1	0.003 <i><u>0.74</u></i>	0.772 <i><u>14.13</u></i>	0.439 <i><u>4.41</u></i>	0.200 <i><u>2.25</u></i>	0.383 <i><u>3.66</u></i>	0.221 <i><u>2.38</u></i>	0.88
EX3	0.003 <i><u>0.47</u></i>	0.909 <i><u>14.03</u></i>	0.298 <i><u>2.52</u></i>	0.090 <i><u>0.93</u></i>	0.664 <i><u>5.35</u></i>	-0.305 <i><u>-2.78</u></i>	0.88

Note: the W_a test of the null hypothesis, $H_0: \alpha=0$, is 0.53 (*p-value .86*)

also robust to the national (Mexican T-bill and returns in pesos) and the foreign (U.S. T-bill and dollar returns) data, to the EWMI or VWMI indices and the

inclusion/exclusion of the December 1994 devaluation economic shock. Independent of the theoretical explanation, (additional risk or irrational behavior) the five-factor model proposed seems to be an adequate tool to explain the behavior of the Mexican stock market during the measured period. This tool will be useful in additional financial applications such as portfolio evaluation, project evaluation, event studies, and corporate finance studies.

V. THE DYNAMICS OF THE FACTORS

In the previous section (Table 3, Panel D), the correlation among the factors is analyzed. However, the correlation is not rich enough to provide specification of the dynamic relationship among the factors. This problem leads to an alternative approach to modeling these relationships at different time lags among all the factors. The vector autoregression technique (VAR) is used to accomplish this task.

Since the publication of the work of Sim (1980), the popularity of analyzing the dynamics of economic systems has increased. The vector autoregression (VAR) is commonly used for forecasting systems of interrelated time series. The VAR approach sidesteps the need for structural modeling by modeling every endogenous variable in the system as a function of the lagged values of all the endogenous variables in the system. A detailed discussion of VAR models is found in Runkle (1987), Giannini (1992), and Hamilton (1994), among others.

The basic VAR form is:

$$Y_t = C_t + A_1 Y_{t-1} + \dots + A_k Y_{t-k} + B X_t + e_t \quad (5)$$

where Y is a vector of endogenous variables, X is a vector of exogenous variables, A_1, \dots, A_k are matrices of coefficients to be estimated, e is a vector of innovations, and k the number of lags to be analyzed. Since only lagged values of the endogenous variables appear on the right-hand side of each equation, there is no problem of simultaneity, and OLS is the appropriate estimation technique.

Table 9 presents the results (t-statistics) of the VAR model where the endogenous variables are the five zero cost mimicking factor portfolios: EWMI over the risk free rate, size, BE/ME, exchange rate and momentum (Mkt, SMB, HML, EXR and MO). Only 12 lags are analyzed due to the limited size of the time series observations (114 months from July 1989 to December 1998). Table 9 shows the 300 coefficients. There is no clear pattern among the dynamics of the system (only nine out of 300 are slightly above a t-value of two). The average of the adjusted R2 for the five equations is -0.018 . This means that there is practically no information available in the VAR system. The findings are consistent with the hypothesis that each factor contributes its own information and is not explained by the others. This makes the five-factor model more robust and enhances the need for each of the factors in the model.

TABLE 9
Dynamics of the Five-Factors: The VAR Model

Table 9 presents the t-statistics of the VAR model:

$$Y_t = C_t + A_1 Y_{t-1} + \dots + A_{12} Y_{t-12} + e_t$$

where Y is a vector of 5 endogenous variables, and the A's are matrix of coefficients to be estimated, and e is a vector of innovation. The endogenous variables are: Mkt is the return in dollars of the EWMI minus the U.S. T-bill. SMB and HML are Fama and French's (1993) factor mimicking portfolios for size and BE/ME. MO is a factor mimicking portfolio for Jegadeesh and Titman (1993) momentum effect. EXR is a factor mimicking the peso/dollar exchange rate. C is the intercept of the model. There are 12 lags for the July 1987 to December 1998 period.

	Mkt	SMB	HML	EXR	MOA
Mkt(-1)	1.84	-0.08	0.27	1.69	0.72
Mkt(-2)	-0.69	0.35	-1.27	-0.92	-0.87
Mkt(-3)	1.47	-0.76	0.48	0.56	-0.01
Mkt(-4)	-0.38	1.31	-1.19	-0.43	0.06
Mkt(-5)	0.91	0.08	0.96	0.75	-1.32
Mkt(-6)	-1.74	1.48	-0.02	-0.16	-0.21
Mkt(-7)	0.18	1.49	0.54	0.05	0.19
Mkt(-8)	0.82	0.27	1.10	-0.81	-0.61
Mkt(-9)	-0.74	-0.03	0.21	-1.26	-0.13
Mkt(-10)	0.70	0.55	2.25	0.31	-0.64
Mkt(-11)	-0.64	1.01	1.37	0.08	-1.77
Mkt(-12)	0.25	0.90	2.18	1.95	-0.86
SMB(-1)	-0.39	0.07	-0.47	0.51	1.33
SMB(-2)	-0.28	-1.31	-0.57	-0.69	-0.53
SMB(-3)	0.44	-1.38	-0.65	0.75	0.94
SMB(-4)	0.25	-0.33	-2.73	0.10	0.88
SMB(-5)	0.40	-1.52	-0.78	-0.50	0.12
SMB(-6)	-0.61	0.06	-2.50	0.58	1.47
SMB(-7)	0.65	-0.41	-1.48	-0.20	-0.17
SMB(-8)	-0.50	-0.10	-1.30	-0.42	-0.30
SMB(-9)	-1.04	0.75	-0.24	0.38	-1.17
SMB(-10)	0.48	-0.31	0.23	-0.58	-0.80
SMB(-11)	-0.81	1.00	-0.37	0.37	-0.40
SMB(-12)	0.18	0.86	1.19	-0.11	-0.36

TABLE 9- continued

	Mkt	SMB	HML	EXR	MO
HML(-1)	0.86	-0.46	0.11	0.26	-1.26
HML(-2)	-0.96	0.48	-1.05	-0.19	0.54
HML(-3)	-0.31	1.13	0.70	-0.87	-0.34
HML(-4)	-0.83	0.82	0.31	-0.30	-1.18
HML(-5)	0.88	0.85	0.50	1.48	-0.53
HML(-6)	0.19	-0.12	1.56	0.33	-1.39
HML(-7)	-1.13	0.96	1.37	-0.58	-0.06
HML(-8)	-0.45	1.64	0.75	0.77	1.20
HML(-9)	1.71	-1.04	0.02	-2.01	-1.40
HML(-10)	-2.17	1.18	-0.56	0.03	1.21
HML(-11)	1.67	-0.81	1.02	-0.23	0.26
HML(-12)	-0.59	0.43	-0.29	0.22	-0.23
EXR(-1)	-1.84	1.11	0.59	-0.82	0.46
EXR(-2)	1.74	-1.21	1.33	-0.45	0.76
EXR(-3)	-1.17	0.49	0.23	0.27	-0.34
EXR(-4)	0.79	-1.93	1.60	0.63	1.50
EXR(-5)	-0.33	-0.39	-0.52	0.36	1.20
EXR(-6)	1.35	-2.72	-1.72	-0.61	0.91
EXR(-7)	0.24	-1.25	-1.50	-1.02	0.91
EXR(-8)	-0.10	-1.05	-0.59	-0.39	0.46
EXR(-9)	0.34	-0.79	0.15	0.29	-0.18
EXR(-10)	-0.88	-0.17	-1.82	0.83	-0.05
EXR(-11)	1.54	-1.63	-0.74	1.39	0.19
EXR(-12)	-0.47	-1.28	-1.30	-0.03	1.10
MO(-1)	-1.00	0.60	0.12	1.11	-0.42
MO(-2)	2.15	-0.71	1.32	1.91	-1.47
MO(-3)	-0.50	0.53	0.64	0.46	-0.63
MO(-4)	-0.57	1.31	0.86	-0.38	-0.72
MO(-5)	-0.72	1.09	-0.91	-0.03	-0.03
MO(-6)	-0.17	0.47	-0.64	-1.45	-0.03
MO(-7)	0.20	0.94	0.35	0.33	1.39
MO(-8)	0.62	-1.58	-1.05	-2.44	1.04
MO(-9)	-1.55	0.59	1.04	-0.11	1.03
MO(-10)	0.26	-1.30	-1.09	-1.01	1.00
MO(-11)	-0.04	1.03	0.52	1.89	-1.33
MO(-12)	-0.16	-0.66	-0.56	0.01	-0.28
C	-0.37	1.17	-1.34	-0.16	0.13

VI. AN ADDITIONAL APPROACH TO TEST THE EXCHANGE FACTOR

The results of Section III, using the factor mimicking technique of Fama and French (1993), suggest that the exchange rate risk factor is an important component. Due to the importance of the results and the fact that it is probably the first time that exchange rate risk is measured with this technique, it is appealing to test the exchange rate risk using the traditional macroeconomic variables as factors methodology. Specifically the Choi, Hikari, and Takezawa (1998) study is followed in this section.

Exchange rate could induce real effects and therefore influence asset returns due to various factors that cause deviations from PPP such as government control and other frictions. In order to test whether the peso/dollar exchange rate fluctuations are priced on the Mexican stock market a two-factor model is tested:

$$Z_i = E(Z_i) + \beta_{iM} Z_M + \beta_{iE} F_E + \varepsilon_i \quad (6)$$

and

$$E(Z_i) = \lambda_o + \lambda_M \beta_{iM} + \lambda_W \beta_{iW} \quad (7)$$

Choi, Hikari, and Takewaza (1998) show that these two equations are equivalent to:

$$Z_i = \lambda_o(1 - \beta_{iM}) + \lambda_E \beta_{iE} + \beta_{iM} Z_M + \beta_{iE} F_E + \varepsilon_i \quad (8)$$

The dependent variables, Z_i , are the returns in dollars over the U.S. T-bill. The portfolios are formed on quintiles of all the Mexican stocks sorted each December $t-1$ by the ex ante beta loading with the percentage change of the peso/dollar exchange rate, and held during year t . Beta loadings are estimated annually, but portfolios are equally-weighted with monthly rebalance to avoid survivorship bias. The period analyzed is January 1991-December 1998 and the period 1988-1990 is used to estimate the first beta-loading to form the Z_i dependent variable. The first factor, Z_M , is the VWMI over the U.S. T-bill. The second factor, F_E , is the orthogonal exchange rate. β_M , β_E , λ_M , and λ_E are the coefficient and premiums of the VWMI and the orthogonal exchange rate factor, F_E . The reason for using orthogonal factors is to eliminate a potential problem caused by possible factor correlation (see Elton and Gruber, 1991). An orthogonal factor is the innovation of the regression of the original factor on the rest of the factors. Table 10 presents the results of the regressions. The iteration was performed with the four iteration techniques mentioned in the Chapter 4. The results with all of them are virtually identical. This implies that asymptotic efficiency is achieved.

The t-statistics of the beta loadings of the orthogonal exchange rate risk factor, β_E , are significant in three of the five regressions. The premium λ_E , is positive and statistically significant at the five percent level.

However, as previously mentioned, some authors argue that the foreign exchange risk premium is just a proxy for a missing bond factor. To check this possibility, it is necessary to include a bond index as a third factor in the model:

$$Z_i = \lambda_o(1 - \beta_{iM}) + \lambda_E \beta_{iE} + \lambda_{iB} \beta_{iB} + \beta_{iM} Z_M + \beta_{iE} F_E + \beta_{iB} F_B + \varepsilon_i \quad (9)$$

Because of the lack of a reliable theory indicating which government bonds should be used, the JP Morgan Mexican Bond Index is employed. Similar to Choi, Hikari, and Takewaza (1998) the first difference of the bond index yield orthogonal to the market and the orthogonal exchange factor is used. This bond index is composed mainly (approximately 80 percent) by the government Brady pair bonds (A and B) and government Brady discount bonds (A, B, C, and D). The rest are Euro-bonds for the AAA Mexican firms. The JP Morgan Mexican Bond Index is value-weighted.

Table 10 presents the results of this three factor model.

Analysis of the beta-loadings and the risk-premium of the orthogonal bond factor make it clear that the bond factor does not help to explain the dependent variable. The bond factor has insignificant effect on the beta-loadings and risk premium of the orthogonal exchange rate risk factor. In both the two and three factor models, the exchange rate factor has positive risk premium statistically significant at the five percent level.

TABLE 10
Market, Exchange Rate and Bond Index Factors,
January 1991 to December 1998

Table 10 presents a two-factor model: $Z_i = \lambda_o(1 - \beta_{iM}) + \lambda_E \beta_{iE} + \beta_{iM} Z_M + \beta_{iE} F_E$
and a three-factor model :

$$Z_i = \lambda_o(1 - \beta_{iM}) + \lambda_E \beta_{iE} + \lambda_{iB} \beta_{iB} + \beta_{iM} Z_M + \beta_{iE} F_E + \beta_{iB} F_B$$

The dependent variables are the returns in dollars over the U.S. T-bill of the quintiles formed on the ex ante beta loading of individual stocks with the percentage change of the peso/dollar exchange rate. Mkt is the return in dollars of the VWMI minus the U.S. T-bill. F_E is the orthogonal peso/dollar exchange rate. F_B is the orthogonal first difference in the Mexican JP Morgan Bond Index. The t-statistics are in underlined italics.

	Two-Factor Model		Three-Factor Model		
	β_M	β_E	β_M	β_E	β_B
Z1	0.607 <u>10.98</u>	0.022 <u>0.19</u>	0.607 <u>10.98</u>	0.020 <u>0.17</u>	0.028 <u>0.29</u>
Z2	0.716 <u>11.61</u>	-0.231 <u>-1.86</u>	0.717 <u>11.62</u>	-0.249 <u>-1.96</u>	-0.030 <u>-0.29</u>
Z3	0.457 <u>9.41</u>	-0.274 <u>-2.61</u>	0.456 <u>9.39</u>	-0.278 <u>-2.63</u>	0.002 <u>0.03</u>
Z4	0.796 <u>15.24</u>	-0.466 <u>-4.18</u>	0.797 <u>15.25</u>	-0.450 <u>-3.97</u>	0.027 <u>0.29</u>
Z5	0.868 <u>12.98</u>	-0.379 <u>-2.78</u>	0.866 <u>13.10</u>	-0.433 <u>-2.99</u>	-0.174 <u>-1.42</u>
	Coefficient	t-Statistic	Coefficient	t-Statistic	
λ_E	0.023	<u>2.23*</u>	0.025	<u>1.96*</u>	
λ_B			-0.035	<u>-0.89</u>	

*Significant at five percent level

This result is consistent with the previous findings using the mimicking risk factor technique where in the five-factor model (Table 3 and 4) significant beta loadings and a positive risk premium are found.

Additionally, a zero cost portfolio with the Bond Index minus the risk free rate was included in the mimicking multifactor model previously discussed. Similar to the three-factor macroeconomic variables model the Bond Index is not statistically relevant. This result is not presented for the sake of brevity.

The fact that with two different methodologies and different dependent variables the exchange risk factor appears as a significant descriptor of returns with a positive premium increases the robustness of the results.

VII. CHARACTERISTICS VERSUS MULTIFACTOR MODEL.

Daniel and Titman (1997) asked whether there are really pervasive factors associated with the mimicking factor portfolios and whether there are risk premiums. They directly test whether the high returns of mimicking factor portfolios can be attributed to their factor loading. Their results suggest that the answer to both questions is negative.

a. Covariance Stability

The first step is to check the covariance stability. Fama and French (1993) argue that the high covariance among firms that load in the same factor is due to their sensitivity to the factor. Then, through time the covariance should disappear as financial distress characteristics improve. However, if the characteristic model is true or a time varying factor risk premium exists, the covariance should remain constant.

To test the stability of the covariance, the Daniel and Titman methodology is followed. Four portfolios are formed based on the intersection of two categories of size (big and small) and two categories of BE/ME ratio (high and low). These portfolios are designated BH, BL, SH, and SL. Furthermore, two zero investment mimicking factor portfolios of size (SMB) and BE/ME effects (HML) are formed and the holdings in each portfolio are maintained for five years before and after the formation year. The portfolios are equally-weighted and the postformation and preformation return standard deviations are calculated. A difficulty with this analysis is that a considerable number of the firms are not traded for the ten year period. The -5 and +5 portfolios contain a substantially smaller number of firms than the lag "0" portfolios. However, Daniel and Titman experimented in this way using only the firms that have reported returns for all the lags and they report that there are no material changes.

Table 11 shows the results of this experiment. On average, the monthly standard deviation is 6.6 percent and as the characteristic model predicts, standard deviation does not tend to vanish. Otherwise, there seems to be a trend to increase in the last lags (-5 and +5). The increase in the last lags may be due to the reduction of the number of stocks in each portfolio. A multifactor model with fixed factor risk premium, as Fama and French (1993) propose, predicts that as the portfolios move off the formation year, the standard deviation should vanish. However, the evidence

TABLE 11
Pre-Formation Monthly Return Standard Deviation of Portfolios

Table 11 presents the simple time-series standard deviation of 6 portfolios based on pre-formation characteristics of the set of size and BE/ME (BH, BM, BL, SH, SM, SL, SMB and HML). The characteristic formed portfolios (year "0") are held for five years (forward looking) and the previous five years (backward looking). The period is July 1987 to December 1998.

Size/BM Portfolios	Formation Year										
	<u>Backward Looking</u>					<u>Forward Looking</u>					
	-5	-4	-3	-2	-1	0	1	2	3	4	5
BH	9.1	7.6	7.8	7.6	7.9	8.6	8.3	8.1	8.5	9.3	9.7
BL	8.6	8.1	8.4	8.5	8.1	7.9	7.7	8.5	8.2	8.1	8.3
SH	7.4	6.4	7.6	6.8	7.4	7.2	6.8	7.5	9.5	8.6	8.1
SL	7.5	7.1	8.1	7.0	7.0	7.2	6.3	5.9	7.3	9.3	10.3
SMB	5.8	4.9	4.4	4.5	4.5	4.8	5.3	5.7	6.0	6.8	7.4
HML	4.0	4.0	4.6	4.2	4.1	4.0	3.5	4.1	5.1	5.6	5.7
Average	7.1	6.3	6.8	6.4	6.5	6.6	6.3	6.6	7.4	8.0	8.3

suggests that at least in the period from July 1989 to December 1998 the standard deviation remained constant. The findings support the use of parametric models, and are consistent with the characteristic model, or with a model with time varying risk premium, but constant beta-loadings.

b. Characteristic or Beta-Loading

In order to determine whether expected returns are described by a multifactor model with time varying factor and risk premium or a characteristics model, Daniel and Titman (1997) create portfolios with similar characteristics but different loading in the mimicking factor portfolio. They find that after controlling for characteristics, expected returns do not appear to be positively related to the loading in the mimicking

factor portfolios. To discriminate between factors or characteristics, Daniel and Titman initiated the following experiment:

- a) Each year stocks are sorted by size into two parts (big and small) and each part is sorted into two parts by BE/ME (high and low). Four portfolios, BH, BL, SH, and SL are obtained.
- b) For each stock at the end of each year from 1990 to 1997 the ex ante β_{iHML} in the equation (2) is calculated.
- c) Each of the four characteristic portfolios (BH, BL, SH and SL) is split by its loading (β_{iHML}) in the HML factor, forming eight portfolios. From July t to June $t+1$ β_{iHML} was calculated ex ante in December $t-1$.
- d) Construction of a matrix of four characteristic portfolios (BH, BL, SH and SL) rows, and two-factor loading (β_{iHML}) columns. Then, eight equally-weighted characteristic-factor loading portfolios are performed and mean returns are calculated.
- e) Estimation ex post is performed in equation (2) for the eight portfolios for all the periods.

Indeed, Daniel and Titman did nine size-BE/ME based characteristic portfolios, and each was divided into five loading categories, forming 45 portfolios. This presented a matrix with nine characteristics rows and 5 loading columns. The characteristic-based model predicts that in each characteristic-based row, the returns should be statistically equal for the different columns. The result is due to the fact that the characteristics (rows) explain the returns and not the loading on the factor (columns). In contrast, multifactor models predict that the if each column has different loading levels, then the returns should be different.

Table 12 presents the results of the experiment described above. Analyzing the ex post β_{HML} for the period the difference between column 1 (high ex ante β_{HML}) and column 2 (low ex ante β_{HML}) is 0.09. This is lower than the difference found by Daniel and Titman (0.37 between columns 1, 2 and 4, 5). The mean returns of the eight portfolios are presented in the two first columns of Table 12. The table reveals an average difference in returns of 0.26 percent per month between high and low β_{HML} columns, which is larger than in Daniel and Titman. (0.03 between the columns 1, 2 and 4, 5). However, it is possible that this positive relation occurs because within the broad categories, a large amount of variation in the BE/ME is picked up sorting on the β_{HML} . Columns 5 and 6 show the BE/ME average of each portfolio, and columns 7 and 8 the size (LN[Size]) average. A variation of 6.6 percent is present between the low and high loading column against the 8.8 percent found by Titman and Daniel (among columns 1, 2 against 4, 5). It is not clear whether the difference in returns is due to the difference in the loading or the variation in the characteristic. Nonetheless, the main problem of distinguishing between factors and characteristics in the Mexican stock exchange is its small number of firms and lack of trading volume. The eight portfolios form very broad categories (compared with the 45 formed by Daniel and Titman), and the number of stocks per month in each category averages only nine with some months containing only four stocks. This produces a lot of specific variance in each portfolio.

TABLE 12

Mean Monthly Returns of the Eight Portfolios Formed on the Basis of Size, BE/ME, and the HML Factor Loading.

Firms are ranked by the BE/ME at the year $t-1$ and their market capitalization in June t . From July 1991 to December 1998 all firms are split in two groups of size and two of BE/ME ratio forming four portfolios (BH, BL, SH and SL). Each of the individual firms in these four portfolios is then further sorted into two subportfolios based on their ex ante β_{HML} coefficient in the regression:

$$R_{it} - R_{ft} = \alpha_i + \beta_{i1}(R_{Mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t$$

Each December from 1990 to 1997 the β_{HML} in December $t-1$ is used from July t to June $t+1$. Table 12 presents the mean monthly returns (in percent) of these eight equally-weighted portfolios, the ex post β_{HML} of each portfolio for the whole period (t-statistics are in italics underlined), the mean BE/ME ratio and the mean natural logarithm of the size.

	RETURNS		BETA HML		BE/ME		LN(SIZE)	
	H- β_{HML}	L- β_{HML}	H- β_{HML}	L- β_{HML}	H- β_{HML}	L- β_{HML}	H- β_{HML}	L- β_{HML}
BH	1.34	1.94	0.341	0.222	1.23	1.19	16.1	16.0
			<u>2.54</u>	<u>2.03</u>				
BL	4.04	3.54	-0.023	-0.208	0.44	0.39	16.4	16.3
			<u>-0.25</u>	<u>-2.35</u>				
SH	-0.97	-1.31	0.402	0.465	1.83	1.67	13.1	12.9
			<u>2.75</u>	<u>3.56</u>				
SL	3.15	2.34	0.102	0.020	0.70	0.68	13.5	13.4
			<u>0.73</u>	<u>0.17</u>				
Ave	1.89	1.63	0.21	0.12	1.05	0.98	14.80	14.65

In conclusion, the broad categories which pick up a lot of variation in the characteristics plus the small number of stocks in each portfolio does not allow the test to discriminate whether the factors or the characteristic provide more precision in describing expected returns behavior.

VIII. CONCLUSION

Unfortunately, the size of the Mexican capital market and the information available is not as complete as in the United States. However, this should not be a reason to abandon the research and accept theories developed and tested in other countries as dogma. Currently, portfolio performance researchers in the United States work with monthly data of about 2,000 funds covering a 30 year period, but it is important to remember that Jensen (1968) worked with annual data of 115 mutual funds over a ten year period (1955-1964, ten time series observations). His results differ from the conclusions of current research, but in spite of all the possible errors committed, his paper is considered seminal. The existing research on the Mexican stock market does not correspond to its size and development. The findings that this dissertation achieves can enlighten the field and open paths for future research.

The first hypotheses (H1) of the present dissertation says that the CAPM is rejected in the Mexican stock market. The evidence presented suggests that the first hypothesis is correct. The CAPM, equation (1), was regressed against ten portfolios designed to contain the risk factors of size, BE/ME, momentum, and exchange rate risk (see Table 2). Similar to the results reported by several authors in the U.S., the CAPM is widely rejected in all the studied period (1989-1998). Table 3 panel A and D show the results of the regressions and the multivariate test.

The second hypothesis (H2) states that the four-factors that help explain stock return variation in the U.S. market: market index, market equity size, book equity-to-market equity ratio, and momentum, are significant in the Mexican market. Table 4,

Panel A shows the premiums for the four-factors described in H2. Panel B presents their t-statistics and p-values showing that market index, market equity size, book equity-to-market equity ratio, and momentum, are statistically significant at a one percent confidence level. These results are consistent with H2, and the four-factors provided information to explain the behavior of the Mexican stock market.

The third hypothesis (H3) sustains that peso/dollar exchange rate fluctuation is a source of risk in the Mexican stock market. It is a factor that helps to explain returns and it is priced. This hypothesis is based on the importance of the international trade in Mexican economy (mainly with the U.S.) and the strong fluctuations of Mexican currency during the studied period. The evidence found shows that the exchange rate fluctuations help to explain the behavior of the Mexican stocks (see Table 3, Panel B) and the factor is priced. The price premium is statistically significant at two percent level (see Table 4).

This is perhaps the most important finding in the present dissertation for several reasons: to the foreign investor, the exchange rate is probably the most important factor. International investors would classify the Mexican market risk in two categories: domestic risk and exchange rate risk. Besides, empirical research in the exchange rate risk is scarce. Following a macroeconomic variables as factor approach (see Chapter 2, Section V) a second test is performed on the exchange rate risk. In this second test, the Choi, Hikari, and Takewaza (1998) experiment is followed. A two-factor model (equation 6) with market and exchange rate as factors is tested. The results are presented in Table 10. With both techniques, (factor

mimicking and macrovariables as factors) results are consistent with H3 that the peso/dollar exchange rate fluctuation is a source of risk and was priced at least in the studied period.

Some authors argue that the exchange rate factor can be a proxy for a missing bonds factor. Then, the long term interest rate could be another factor that helps describe returns. To test this possibility, an orthogonal interest rate factor, proxied by a bond index, is included (equation 9). The results suggest that in the Mexican stock market during the July 1989 to December 1998 period, the long term interest rate did not help to explain returns and did not change the statistical significance of the exchange rate factor.

It is important to remark that the trade agreements between Mexico and the U.S., the increase in efficiency of the Mexican market, and the development of the U.S. and Mexican peso/dollar derivative product markets, could minimize or eliminate the premium of the exchange risk factor. In other words, when barriers between the U.S. and Mexico markets disappear, both markets become fully integrated, and the PPP remains constant between both countries, international investors will care only about Mexican domestic risk and not be concerned with exchange risk.

Joining H2 with H3, a five-factor model (equation 4) is performed. This model is regressed against ten portfolios designed to contain size, BE/ME, momentum, and exchange rate risk. The five-factor model is not rejected by a battery of multivariate tests (see Table 3, Panel D). This multivariate tests include: a Wald adjusted test, a

Likelihood adjusted test, and a Wald GMM test. The statistical significance of the factors coefficients, the premiums, and the multivariate tests (See Table 3 and 4) suggest the five-factor model is a clear improvement over the CAPM and is at least an adequate tool to describe the behavior of the Mexican stock returns in the 1989-1998 period.

However, the results so far presented could be distorted by the fact that returns are in Mexican pesos and an important share of the Mexican market is foreign investment. Another important fact could be the use of EWMI or VWMI. The experiment discussed to test the H1, H2, and H3 was repeated but under the foreign investor viewpoint, using returns in dollars and the U.S. T-bill as risk free rate. Table 5 and 6 present the results for the CAPM and the multifactor models. They are similar that in the former experiment (Mexican peso and Cetes as risk free rate). The CAPM is rejected at one percent, and the five-factor model is not rejected at ten percent significant level during all the period. Additionally, the experiment is repeated using the VWMI instead of the EWMI. Table 8 shows the results of the regression of the five-factor model. The SMB suffers some distortions due to its correlation with the VWMI. However, the five-factor model is not rejected and the conclusion remains the same using VWMI or EWMI.

The fourth hypothesis (H4) suggests that the pricing model developed in this dissertation should be robust to the inclusion or exclusion of the effects of the December 1994 currency devaluation and economic shock suffered in Mexico. In order to test H4, an experiment was conducted eliminating the adjustment period

(December 1994 through September 1995) to see whether the results so far presented are induced by this devaluation economic shock. Table 7 presents the five-factor model regression for the data period, but eliminates the December 1994 to September 1995 data. The results suggest that the explanatory power (the adjusted R²'s, beta-loadings, and intercepts) of the model is not increased. This is consistent with H4, meaning that the five-factor model coefficients are robust to the inclusion or not of the December 1994 shock.

Hypothesis 5 (H5) suggests that each factor must provide its own information to the model and the factors should be serially uncorrelated, and a VAR model that includes all the factors of the pricing model (equation 5) should be statistically insignificant in all the leads and lags. To check H5 a VAR model where the endogenous variables are the five zero cost mimicking factor portfolios (EWMI over the risk free rate, size, BE/ME, exchange rate and momentum) is performed. The results are presented in Table 9 and does not show any clear pattern among the dynamics of the system. The average of the adjusted R² for the five equations is very low (-0.018). This means that there is practically no information available in the VAR system. These findings are consistent with H5 in the sense that each factor contributes its own information and is not explained by the others.

The last hypothesis (H6) of the present dissertation is that in the Mexican stock market, the characteristic describes the stock returns better than the factor beta-loading. To test the H6, the Daniel and Titman (1997) experiment was followed with some adaptations to the size of the Mexican stock market, (see the description of the

model in Chapter 2, equations 1 to 6). The first step is to check the stability of the covariance matrix. If the characteristic matters or there is a time varying factor risk premium, the covariance should remain constant. Table 11 shows the results of this experiment. The covariance seems to be stable during the studied period which is consistent with the characteristic model, or with a model with time varying risk premium, but constant beta-loadings. To discriminate between the characteristic model and a model with time varying risk premium, a second experiment is necessary. Basically, there are formed portfolios with similar characteristics but different loading in the mimicking factor portfolio to analyze if the characteristic or the loading explains the returns. However, the number of stocks in the Mexican stock market only allows the formation of only eight portfolios instead of the 45 formed by Daniel and Titman. Besides, the number of stocks per month in each category averages only nine with some months containing only four stocks (this produces a lot of specific variance in each portfolio). This specific variance avoids the test to discriminate whether the factors or the characteristic provide more precision in describing expected returns behavior (Table 12). Then, there is no clear conclusion in the experiment performed to test the H6, but the results of the first step (were covariance stability is tested) are consistent with the characteristic theory of Daniel and Titman.

Concluding, the CAPM is rejected and the five-factor model is not rejected. Market, size, BE/ME, momentum, and exchange rate are significant factors in the Mexican stock market. These results are robust to the use of the returns in pesos or

dollars, Mexican or U.S. T-bills, inclusion or exclusion of the December 1994 devaluation economic shock, and the use of an equally-weighted or value-weighted market indices. Besides, the peso/dollar exchange rate is significant using the mimicking or macrovariable factors technique.

So far, the explanation of the meaning of these factors is controversial. However, a model with an adjusted R² of 87.5 average, and an intercept statistically non different from zero at the five percent level, and significant beta-loadings, could be an important tool for several financial applications.

CHAPTER 6

GENERAL CONCLUSIONS AND LINES OF FUTURE RESEARCH

The history of asset pricing theory began in 1964 with Sharpe's CAPM model. During more than three decades of existence, many different and varied opinions have been expressed. It is important to state that a consensus has not been reached and there are numerous resources and many researchers working in these areas. The reason for the intense research in pricing models, besides direct application to investment strategies and understanding of the stock market behavior, is its strong link with portfolio performance evaluation and corporate finance. Results in empirical research in portfolio performance and corporate finance are very sensitive to the pricing model used.

Formal research in asset pricing models in Mexico is necessary due to the scarcity and lack of existing studies. Financial development is important to a developing country where the principal commercial partner is the U.S. and the country is immersed in global financial markets.

The general objective of this dissertation was to explain the Mexican stock returns during the period of July 1989 to December 1998. Specifically, the objectives are to provide empirical evidence that: the CAPM did not hold in the Mexican stock market; four-factors are significant (market index, size, BE/ME and momentum); the

peso/dollar exchange fluctuation is a source of risk; and based on Daniel and Titman (1997), characteristics explain the stock returns better than the beta-loadings.

The results achieved reject the CAPM at the one percent level, suggesting that this model is not adequate to explain the Mexican stock behavior. Following the mimicking factor technique, a five-factor model is developed: a market proxy, size, BE/ME, peso/dollar exchange rate, and momentum. The results suggest that these five-factors are significant in explaining the cross-sectional variation in the Mexican stock market, and the model is not rejected at the five percent level in a battery of multivariate tests. These results are robust to: the use of returns in dollars or pesos; the use of the U.S. or Mexican T-bill as risk free reference; the inclusion or exclusion of the December 1994 devaluation economic shock; and the use of value-weighted or equally-weighted market indices.

To study the dynamics of the five-factors through time, a VAR is presented and indicates that there are no significant relationships among the factors. This result is important and consistent with the hypothesis that each factor provides its own information to the model and is not predicted or explained by lead or lag values of other factors.

This may be the first study using the mimicking factor approach to describe exchange rate risk. The traditional approach is the use of macroeconomic variables as factors. In order to increase the robustness of the exchange rate factor results, the experiment is repeated, but using the macroeconomic variables as factor approach. With both techniques, the beta-loadings are significant and the premium is positive

and statistically significant at the two percent level. This result is robust to the inclusion in the model of the interest rate factor. It is interesting to remark that in both techniques (mimicking and macroeconomic variables as factors) the interest rate factor is insignificant during the total period.

It is important, as Daniel and Titman (1997) argue, to find if in fact the factor's beta-loading or the characteristic per se (i.e., β_{HML} vs. BE/ME) of the factor explains the returns. However, the small number of firms in the Mexican stock market during the period studied did not allow the test to discriminate whether the returns are more sensitive to the factor's beta-loading or to the characteristics per se.

The present study provides several areas of future research. More investigation to discriminate between factor's beta-loading or characteristics is important. The small size of the Mexican stock market will challenge the development of special methods for factor's beta-loading vs. characteristic comparisons and finite sample testing.

Several event studies, such as dividend announcements, January anomaly, and efficiency, have been made with the CAPM used as a benchmark. With the development of a powerful pricing model these studies could be repeated and compared so as to examine the sensitivity of these events to the benchmark model. Other interesting event studies, such as herding behavior, IPOs, and repurchase of shares, could be reviewed using the pricing model developed in this dissertation.

Another important line of future research is the area of portfolio performance. Since May 1997, end of month holdings of mutual funds are available in electronic files. In a few years, sufficient data will be available to compare the advantages and disadvantages of the use of multifactor models or a characteristic model as a benchmark in portfolio evaluation. Additionally, in November 1996, the state-owned pension fund system was privatized. A private pension fund system named AFORES, similar to the Chilean system, was created. [AFORES are the pension funds of all Mexican workers and selection of an AFORE is a free choice]. There are 22 private AFORES, but they are limited to investing in fixed income securities. When AFORES become free to invest in the stock market, it will be interesting to evaluate their performance. Measuring fund performance using a well recognized method and publishing results will be fundamental to the health of the system.

Along with the evaluation performance of the mutual fund industry, it is also important to adapt the evaluation methodology to particular cases such as a treasury portfolio or a corporate fund. General managers would welcome an objective method to measure the performance of portfolio managers.

In conclusion, the results found in the present dissertation are consistent with the hypotheses presented in Chapter 1, although in the comparison between factor loadings vs. characteristics the results are vague and not conclusive. However the overall proposed objective of this dissertation has been achieved.

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