INTEGRATION, DIVERSIFICATION, AND SPILLOVER:
An Assessment of the Emerging Markets Using American Depositary Receipts (ADRs)

Delroy M. Hunter

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Acknowledgement

This thesis is dedicated to my son Machel. It is my hope that his struggles will be more fruitful than mine.

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Abstract

The focus of this thesis is on the emerging markets. It assesses intra- and inter-market mean and volatility spillover, investigates the impact of the Mexican currency crisis on international portfolio diversification, and employ international asset pricing to test the integration of the emerging markets.

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Chapter 1. Introduction

The main thrust of this thesis is International Finance. Within this framework, it investigates intra- and inter-market transmission of returns and volatility, international portfolio diversification, and empirical international asset pricing. Market integration, fundamental to many issues in finance, is the connecting issue of the various sections of the thesis. For instance, the cost of capital is country-specific in segmented markets, causing capital projects with perfectly correlated cash-flows to have values that differ across countries, and option pricing depends on the integration of the option, bond, and underlying asset markets. Hence, integration may be considered not only across national markets, but also within national borders.

Markets are fully integrated if assets with perfectly correlated returns have the same price in a given currency regardless of the market within which they trade. Similarly, if two assets have identical risks, then they should be priced to yield the same *expected* returns. On the other hand, segmentation exists if two assets of equal risk have different expected returns. In either case, risk is measured by an (international) asset pricing model without the assumption of investment restrictions.

The emerging markets are the focus of this thesis. Recently, these markets have become important in the international capital markets. For instance, in the period 1990 to 1996, the emerging stock markets attracted a total of over $230 billion of foreign capital, swelling their market value to $2.1 trillion or 10.7% of total world equity capitalization. Over $53 billion has been invested in American Depositary Receipts

(ADRs) and about $115 billion flowed into country funds. In 1996 alone, about $45.7 billion of foreign capital was invested in the emerging markets. Latin America has been the largest beneficiary of this inflow, attracting $16.5 billion in 1996, more than the $12.9 billion going to East Asia and the Pacific. In 1996, 144 of the 556 ADRs issued by 42 countries raised $8.9 billion for the emerging markets. This is compared to $38.9 billion raised locally (see Appendix A).

In this the first chapter (**Chapter 1**), I present an overview and outline the scope of the thesis.

Chapter 2 describes the institutional features of the ADRs market and the costs and benefits to the several parties involved in the ADR program (see Appendix C for a list of the ADRs used in this thesis). As a precursor to the empirical essays, the chapter also briefly examines several features pertinent to measuring risk and return in the emerging markets where thin trading is usually a problem. These include the "beta bias" caused from the "intervaling effect" and autocorrelation in the indices. Some remedies are discussed also. The chapter closes with a discussion of the selection of an index, the purposes of an index, and the different types of indices used in industry. Appendix D documents the technical issues that I considered in the cases where I constructed an index.

Chapter 3 of this thesis defines integration, reviews the literature on the means of testing market integration, and summarizes the empirical results for developed and emerging markets. The factors which aid the integration of capital markets, the effects of barriers to international investments, and the various barriers to international capital market investments are documented next. I then discuss the measures employed by emerging markets to overcome segmentation, chief of which is the cross-listing of their stocks on exchanges in the developed economies (see Appendix B). The various implications of this action are also documented.

Chapter 4 reviews the international asset pricing literature and provides a summary of the various models, their assumptions, and resulting predictions for optimal portfolio holdings and expected returns. The review follows the classification common in the literature by outlining the nature of the problem the asset pricing models attempt to solve; that is, whether or not they consider the exchange-risk dimension which arises as a result of deviation from Purchasing Power Parity (PPP) and which leads to differences in the consumption opportunity sets across countries or the segmentation issue which gives rise to differences in investment opportunity sets across countries.

Chapter 5 reviews the primary econometric techniques employed in the empirical sections of the thesis - Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models and Mean-Variance Spanning. Univariate and multivariate GARCH models are discussed and their features are related to the characteristics of speculative asset prices and asset pricing. The development and use of Mean-Variance Spanning, including its generalization from the original CAPM-based model to one consistent with the Latent Variables asset pricing model, is outlined in this chapter.

Three related empirical topics are then examined using the American Depositary Receipts (ADRs) and country funds of Argentina, Chile, and Mexico. The *first* empirical essay (**Chapter 6**) investigates the transmission of mean and volatility between the Mexican market, the Mexican ADRs, and the US market, between the Mexican ADRs and their underlying stocks, and between the Mexican ADRs and the ADRs from the rest of Latin America.

The motivation for these tests are two fold. First, they are done in a framework which allows us to make inferences about the integration of the Mexican market. If the Mexican market is integrated, then the ADRs and their underlying stocks should impound relevant market information at the same rate. There should be no lagged spillovers (called "reverse" spillovers) between them. There have been various tests of integration not only in the developed markets, but recently also in the emerging markets. There are conflicting results from the tests of integration of the Latin American markets.

Second, there is evidence in the literature that the country funds of the emerging markets behave more like US assets. It is expected that the ADRs of the emerging markets should also behave like the stocks of the US market, reacting more to global market news rather than to home-market information. However, there are factors unique to ADRs which could cause them to behave differently from the country funds. This then is also investigated in the first empirical essay.

The *second* empirical essay (**Chapter 7**) examines, from the standpoint of a US investor, the impact of the Mexican peso crash of December 1994 on the diversification obtained from investing in Latin American ADRs and country funds (Appendix E gives a synopsis of the crisis). Several recent papers find that there is diversification from investing in the emerging markets. While these markets generally have higher average returns, they also have higher volatility, time-varying correlation with the developed markets, and have a higher probability of experiencing catastrophic events such as large devaluations and economic and political upheavals.

One important question for foreign investors, therefore, is what is the impact of these events on the gains from diversification? I employ conditional mean-variance spanning tests, estimated with the generalized method of moments (GMM), to determine if investing in the Latin American assets benefited the US investor who held the S&P 500 and other assets and to investigate the effect of the peso crash on these benefits.

The *third* empirical essay (**Chapter 8**) achieves several objectives, primary among them is a direct test of the integration of the Latin American markets in a manner that overcomes the joint hypothesis problem associated with tests of integration using an asset pricing model. In the first section I characterize the volatility of the Latin American ADRs and their underlying assets. I assess the predictability and persistence of their volatility and investigate if global instrumental variables have incremental predictive information for the volatility of the assets. I also test if there is asymmetric response in volatility to events such as bad news in the equity market. The specific features of the volatility of Latin American assets that are observed in this section aid in the specification of the conditional variance to be employed later in the chapter.

In the second section I explore the pricing of the Latin American assets using a specification of the International CAPM in which the risk factors are the conditional covariance with the world market portfolio and the conditional covariance with a world currency index. Specifications consistent with the assumptions of full integration and mild segmentation are used. For instance, I conduct a direct test of integration by specifying a general conditional model in a system of equations in which the time-varying prices of risks are not restricted to be equal across markets for the ADRs, their underlying stocks, the world portfolio, and the world exchange rate index. This test, applied to the ADRs and their underlying stocks, also overcomes the joint-hypothesis problem associated with testing market integration using an asset pricing model. Various tests of robustness, such as assessing the relation between the expected returns of the Latin American assets and their own variance, are executed.

The concluding chapter (**Chapter 9**) summarizes the main research questions and results of the thesis. It also discusses the scope for further work and highlights some areas in which the thesis could have been improved.

Chapter 2. Institutional Features of the American Depositary Receipts Market

I. Introduction

The financial instrument of main interest in this thesis are the ADRs of the Latin American region. In this chapter I discuss the institutional arrangements of the ADRs market. Additionally, it reviews the problems associated with thin-trading which is usually exaggerated in the emerging markets and mentions some attempts that have been made to overcome them. Finally, it examines the types of indices which are used in industry and points to best practices in selecting an index.

II. Definition of a Depositary Receipt (DR)

A Depositary Receipt (DR) is a *negotiable certificate* each representing a fixed number of shares (or units of debt) of a foreign company. The DR is issued in the host market (herein after, the US) by a *depositary bank* guaranteeing that a proportionate number of the foreign shares has been deposited in a *custodian bank* domiciled in the country of the company whose shares are represented by the DR. Usually the DR is created when a broker in the host market acquires the shares of a company which he then deposits in a foreign custodian bank. The latter then instructs the depositary bank to issue the appropriate number of DRs to the broker.

These negotiable units and their dividends are denominated in US dollars. They enjoy the same legal and trading status as US securities and trade on a US exchange (such as the NYSE, AMEX, or NASDAQ) or in the non-NASDAQ over-the-counter (OTC) market. The DR is called an American Depositary Receipt (**ADR**) essentially as a marketing device in the case where it trades only in the US. There is no legal, operational, technical, nor administrative difference from the Global Depositary Receipt (GDR), so called simply to reflect the fact that its market place extends beyond the shores of the US. International Depositary Receipts (IDRs), however, are denominated in one or more non-US international currencies, are usually issued in bearer form to provide anonymity to the owner, and trade primarily in Europe (BNY (1996a)). There are *two categories* of DRs and *four levels* at which they may be registered in the US.

III. A. Types of ADRs Programs: Unsponsored DR Program

The unsponsored DR program is a process whereby a company's shares are traded in the host market purely on account of the depositary bank's attempt to satisfy unmet host demand for a foreign stock. There is no legal covenant between the issuing company and the depositary bank, and the company does not promote nor bear any cost of promoting the program. Since 1983 there has been a downturn in the number of unsponsored DR programs, which are difficult to monitor and carry hidden costs.

III. B. Types of ADRs Programs: Sponsored DR Program

The sponsored program results from a foreign issuer's desire to tap into the US market, and this is achieved by entering into a contract (Depositary Agreement) with a depositary bank to establish and promote the DR program overseas. Under this agreement the DR may be listed on the main exchanges of the US and may be used to raise capital (in addition to achieving other benefits). The sponsored DRs trade in the US as a Level I, Level II, Level III, or Private Placement (Rule 144A) security.

IV.A. Sponsored Level I Program

This is a cost-effective means for a foreign company to access the US market without having to change its local reporting process to meet the US Generally Accepted Accounting Principles (GAAP) and the Securities and Exchange Commission (SEC) disclosure requirements. No registration of the underlying stocks is required. Only the DRs are registered with the SEC. Under the *information exemption* clause of the Securities Exchange Act (1934), the reports and information filed should be in English but otherwise are not different from what is required in the company's local market. The securities trade in the non-NASDAQ over-the-counter market (pink sheets and Electronic Bulletin Board) where a customer base is built before exercising the option to upgrade to the other levels. This level has two main disadvantages; it is merely a listing arrangement so no new capital can be raised, and because of the OTC listing the company does not achieve maximum publicity.

IV.B. Sponsored Level II Program

The foreign company can opt for an exchange listing which allows it to trade on the main US exchanges. The registration requirements are similar to the Level I program but the reporting and disclosure requirements imposed on the cross-listed security by the SEC are the same as those for host securities, and the stock exchange rules must be adhered to as in the case of a domestic company. These are costly and stringent requirements that offer the benefits of a more high-profiled placement in the US market and improved liquidity. As in the case of the Level I program no additional capital is raised under the Level II listing.

IV.C. Sponsored Level III Program

This is a public offering of foreign securities under the Securities Act (1933) and is pursued by companies intending to raise capital in the US and list on either AMEX, NYSE, or NASDAQ. Full registration of the local securities and the DRs is required, and reporting and disclosure are executed pursuant to the Exchange Act (1934) which stipulates full compliance with the US GAAP and the rules of the listing exchange. These requirements impose substantial burdens not the least of which is the continuous reporting cost. However, in addition to the capital raising function, the listing maximizes visibility and liquidity, and in sufficient numbers has important efficiency implications for the local market.

IV.D. Private Placement (Rule 144A) DR Program

This is another means of accessing and raising capital in the US through the Sponsored program. This arrangement is governed by Rule 144A of the SEC which allows the foreign company to offer blocks of DRs to Qualified Institutional Buyers

(QIBs) including insurance companies, investment companies, business development companies, other institutions (each of which must manage a minimum of $100m), and individuals (investing at least $10m). No SEC registration is required nor is compliance with the GAAP and the disclosure provisions, but no public offering can accompany the placement. Any information relevant to the offer must be provided to the potential buyers. A subsequent market between these sophisticated buyers can develop or the DRs may be canceled for the underlying shares in their home markets. The prime benefits of issuing a private placement are raising capital expeditiously and at a relatively cheap rate, increasing the liquidity of the shares, and creating a client base in the US prior to ascending to another rung of the market. Since 1993 there has been a substantial decline in the 144A market (Velli (1994)).

IV.E. Direct Listing (Ordinary Share Program)

Not all companies listing overseas select the ADRs program, but instead may list as ordinary shares. This burdens the issuing firm with the extra administration and legal costs of opening two separate share registers. Additionally, the US share transfer agent and registrar keeps a register of US shareholders while the firm maintains one of local investors. Transactions are accompanied by offsetting debit and credit entries in either register and may result in a physical paper trail which could lead to settlement delays as two systems are now at work. The direct listing loses the services of the depositary bank in the inter-market trades. The Canadian companies listed in the US are direct listings.

V. Other (Practical) Considerations in the Cross-Listing Decision

Whereas academics may be concerned almost wholly with the fact that cross-listing mitigates the effects of segmentation on firms (see Chapter 3 for more on this), the motivation of corporate managers' for listing overseas may be the secondary benefits to be enjoyed by the corporation. Additionally, there are several parties which are affected by the cross-listing process including the firm, its local shareholders, local stock brokers, the investors in the host market, and the depositary and custodian banks.

V. A. Benefits to the Corporation and to Local Shareholders

The local participants enjoy several benefits associated with cross-listing, including:

1. improved access to foreign debt markets and a signaling of strength to potential creditors,
2. increased shareholder base which reduces the possibility of a takeover while increasing its capacity to make its own foreign acquisitions,
3. greater prestige in the local and overseas market place and better corporate relations with host government and citizens, especially if it expects to or is conducting foreign direct investments in the host country; reduced political risk is a spin-off therefrom,
4. increasing the liquidity of the stocks, which reduces risk,
5. price stability arising from increased demand and improved liquidity.

Some of the potential benefits will be offset by the extra costs associated with listing in overseas markets. There will be substantial listing and recurrent exchange fees, increased information to overseas analysts and to the stock exchange, different standards and frequency of reports, disclosures which may be advantageous to competitors, and exposure to possible price manipulations on foreign stock exchanges against which domestic laws cannot provide protection.

V. B. The Host Market Investors

Investors benefit by having the depositary bank conducting all foreign currency transactions, necessary for the repatriation of dividends and capital, on their behalf. Thus they avoid inconvenience, and by transacting in their own currency they also save on costly commissions on foreign currency transactions. Investors also obtain the best rates of exchange as a result of the pooling of funds by the depositary bank and avoid the custodian fees they would otherwise pay by investing on their own behalf in the foreign markets. In short, they have a relatively easy access to foreign markets and a cost-effective means of obtaining international diversification at home. Additionally, they evade exposure to unreliable settlement, custody, and transfer systems, alien tax regimes and exotic trading practices, and are faced with lower information gathering and monitoring costs, relative to trading on their own in the overseas market.

V. C. The Role of the Depositary Bank

In the case of Sponsored ADRs, the depositary bank is contracted by the issuing firm and plays a key role in the DR process. Primarily, it maintains a register of the DR holders separate from a register of all the ordinary shares which is kept by the issuing company. The bank provides services such as the collection and payment (in US dollars) of dividends; serves as a liaison between the foreign market and the host investors; and acts as a conduit for the transmission of relevant market and company information to the DR owner, thus, facilitating her involvement in such activities as proxy voting at annual general meetings and participating in rights and bonus issues. This intermediary role as a depositary bank, a transfer agent, and a registrar, is the major demarcation between ADRs and direct listings.

For its services, the depositary bank earns substantial fees. The relation between firm and depositary bank may extend into areas such as the underwriting of future issues. The depositary bank obtains additional income from charges to brokers and arbitrageurs who execute inter-market trades, e.g., by redeeming ADRs and repurchasing the underlying stocks to benefit from temporary misalignment in prices. Such transactions represent about 2% of volume and so have little impact on prices.

V. D. The Role of the Custodian Bank

The custodian bank's fundamental role is to safeguard the foreign securities upon which the DR program is built, but it may occasionally be required to acquire or dispose of shares held in its custody. Additionally, it gathers information, votes on behalf of the receipt holders, and executes any other transactions pertaining to the business of buying and selling shares as directed by the depositary bank to whom it is employed. To function efficiently the custodian bank must be familiar with the laws governing the local securities market.

VI. Thin Trading in the Emerging Markets

VI. A. Introduction

This section provides a brief overview of the problems caused by infrequent trading of the constituent stocks of the market index. It is generally accepted that the biases caused by thin trading are likely to exist to a greater degree in emerging markets and may even have different underlying causes. Errunza and Losq (1985b) note that the "environments..." of these markets "...are very different from those encountered in traditional markets." Harvey (1995) states that "little is known ... about how to measure the risk of investment in emerging markets...;" a point supported by Eftekhari and Satchell (1996).

VI. B. Systematic Risk and Measurement Problems

Several studies have demonstrated that estimates of systematic risk suffer from serious biases which lead to incorrect pricing of risk if left untreated. For instance, estimated beta changes systematically with the period or differencing interval over which returns are measured (e.g., Altman et al. (1974), Pogue and Solnik (1974), Levhari and Levy (1977), Smith (1978), Hawawini (1980) and Cohen, Hawawini, Maier, Schwartz and Whitcomb (CHMSW) (1983a), Fung, Schwartz, and Whitcomb (1985)). This is called the *Intervaling Effect.*

Additionally, beta suffers from biases arising from delays in the adjustment of stock price to new information (e.g., CHMSW (1980, 1983b), CMSW (1978, 1979, 1986). Given a fixed return differencing interval a stock which experiences more (less) price adjustment delays than the market will have its beta biased downward (upward). Similarly, for a given differencing interval Scholes and Williams (1977) and Dimson (1979) have shown that for a security which trades more (less) frequently than the rate implied by the index used in the calculation of its beta, there is an upward (downward) bias in the estimated beta. These are related biases and may be called the *Nonsynchroneity or Thin-trading Bias*. It is expected that a stock which trades more frequently than the index will have less price adjustment delays resulting in both cases in an overestimated beta.

The implications of such empirical observations are vast and may have led to erroneous conclusions in studies which have not suitably accounted for them. McInish and Wood (1985) note that studies based on time-partitioned returns will be affected by the above biases if not controlled for. Roll (1981) proffered an alternative explanation for the apparent ability of small firms to post positive excess returns not generated by their estimated betas. If small firms trade less frequently than the market index which is used to compute their betas, then their OLS betas (estimated by the market model using short-interval returns) will be underestimated hence their observed returns will be considered greater than their expected risk-adjusted returns. Small firms are also expected to be more affected by persistent price-adjustment delays (see CHMSW (1980) p. 253, footnotes 7,8,9). Hence, the twin effects of these delays will seriously cause underestimation of small firms' beta risk and, therefore, may hold part of the answer to the puzzling "anomalies" that have been observed in the literature. These include the small firm (size) effect (Banz, (1981)) even though it does not explain why the effect is concentrated in January, the price/earnings (P/E), effect (Basu (1977)), and the dividend yields effect. Dimson and Marsh (1983) point to the claim that betas in France and Belgium (see Altman et al. (1974) and Hawawini and Michel (1979), respectively) are more stable than those of the US markets as being a deception of stability due mainly to thin-trading bias. Claessens et al. (1995) find firm size to be positively related to returns in some emerging markets and that liquidity, not illiquidity, has significant premium (see e.g., Brennan and Subrahmanyam (1996)).

VI. C. Factors Causing Biases in Estimates of Systematic Risk

The market model assumes continuous trading in the market's securities. This is an assumption more strongly violated by stocks with relatively low market value. Furthermore, in the markets based on batch or call trading, securities are neither traded continuously nor synchronously. Beta, in the market model, reflects the assumption of informationally efficient markets where market-wide information is fully, quickly and correctly reflected simultaneously in all securities. CHMSW (1980) and McInish and Wood (1986) point to two general classes of friction which can affect the estimated beta. These are price-adjustment delays and trading delays.

Price-Adjustment Delays. Price adjustment delays are caused by frictions in the trading process which dampen the speed with which prices reflect relevant new information. These delays are partly responsible for the intervaling effect. One assumption of the market model is that the security's beta is invariant to the interval over which the returns are calculated. In other words, beta estimated from daily, weekly, monthly, or any other time intervals should be the same. Evidence is that the estimated beta differs systematically across securities and with the period over which returns are compounded. There are several possible causes of price-adjustment delays.

These include *transaction price adjustments lagging changes in quotation prices.* They result from the stock exchange arrangement where the closing price reported for each security occurs at the last transaction which may take place at some point prior to the end of the trading day. Quotation prices (bid-ask) are made throughout the trading session and may be recorded subsequent to the last transaction. This leads to the closing price not reflecting the most up-to-date information relative to the closing quotes.

Another cause of adjustment delays is *inventory balancing by specialists*. This effect is experienced in two different ways. The raison d'être of the specialist is to make timely intervention to bring stability to the market. Her countervailing effect on the price of thinly-traded stocks leads to a slower adjustment to new market information.

Furthermore, in a situation where the specialist is faced with an unbalanced portfolio due to existing market information she will position her inventory to remove this imbalance, even in the face of new information which would suggest a different trading strategy. This latter action may not impound into her quotes the current relevant news, hence, will be a cause of price adjustment delays.

Transaction costs may also cause delays to adjustment of quotation prices. Goldman and Sosin (1979) have demonstrated that under the market imperfection of transaction costs a speculator/investor may find it more cost effective to delay her reaction to new information and to accumulate data over some period before it becomes profitable to trade. At the point of trade the transaction is guided by a mix of new and out-of-date information. Errunza and Losq (1985b) support this view, stating that the real cost of funds to speculators in emerging markets is likely to be higher due to financial intervention from governments and other market imperfections. Furthermore, if the speculator/investor makes a market order that is reacting to the current information and is met by an old limit order the transaction will be completed at a price which impounds previous information. Goldman and Sosin show that, given there is uncertainty in the dissemination of information to other speculators/investors and providing the market does not trade continuously, the level of "efficiency" may be maximized by aggregating data/information and delaying trade. Market structure and trading frictions, therefore, can lead to delays in price adjustment.

CHMSW (1980) categorize these delays on the basis of their endurance in the market place. *Transitory delays* are those which are short lived since there are negating forces within the structure of the market. The transaction price lags the quotation price only until the next trade takes place, which, in continuous markets where securities are frequently traded, may be a relatively short time. This continuous trading results in limit orders not being left for extended periods on the book. Large, efficient markets characterized by price resiliency would correct the impact of the specialist, making an orderly market in some securities. Markets considered deep would be able to accommodate large orders thus reducing the need to break large transactions into smaller orders which tend to cause price adjustment lags since the various sub-orders would most likely be priced to reflect dated information, a fact made relevant since they would at best be filled contiguously.

Protracted price adjustment delays, on the other hand, are not to the same extent mitigated by the forces of the market and, therefore, have greater potential for biasing the estimation of systematic risk. The duration of the specialist's attempts at balancing her portfolio and the speculator/investor's practice of accumulating small bits of new information until she considers the return from trading sufficient to compensate her for the cost of trading - information, decision, and transaction costs - are included in this type of delay.

From the above arguments about the relative persistency of the causes of price adjustment delays it is clear that there is an inverse relationship between the return interval and the effect/impact of the delays. Similarly clear should be the fact that markets which are less deep, resilient, efficient, and where specialists are not employed and trading is not continuous, the market's reaction to and ability to counter these delays will be very different. In a statistical sense, the price adjustment delays give rise to autocorrelations and intertemporal serial cross-correlations in the returns of individual securities and portfolios (see Hawawini, (1980)).

Trading Delays. Closely related to the problem of price adjustment delay is the phenomenon of trading delay. In the literature it is called by various names but most frequently by nonsynchronous trading. In this thesis it is defined to capture the scenarios which are likely to be experienced in emerging markets. *Nonsynchronous trading* describes the situation where the constituent stocks of an index are not traded simultaneously. *Nontrading* is a more extreme case where there is no trading for one trading day or more. *Thin trading* encompasses both levels of infrequency in trading. The justification for this triad of definitions stems from the fact that in the context of developing markets the phenomena defined have different impacts on the assessment of risk and to varying extents are artifacts of the market structures and trading arrangements.

Nonsynchronous trading causes pronounced positive serial correlation in daily stock index returns. This was first pointed out by Fama (1965) who found positive autocorrelations in daily stock returns lagged one day, while Fisher (1966) was the first to point to nonsynchronicity as a probable cause. Roll (1981) states that the autocorrelation observed is "spurious and is simply the result of a defect in our record of prices". Lo and MacKinlay (1990) explain the phenomenon thus. Consider stocks i and j with returns that are independent of time but that i trades less frequently than j. Market-wide news arriving towards the end of the trading day will more likely be impounded in the closing price of *j* since it has a greater probability of having a transaction. Security *i* on the other hand might have had its last trade earlier in the day, prior to the arrival of the new information. Its closing price therefore reflects stale information. On the next trading day or at the time of the next transaction in *i* the price will incorporate the past information. This lag results in spurious cross correlation between the closing prices of *i* and *j*. Portfolios including these securities will display time dependence in their returns even in the presence of a return generation process which is time independent.

A market index can experience nonsynchronous trading as outlined above but providing that there is at least one transaction in each security on each trading day the extent of the lag in the price adjustment is reduced. When there is nontrading in the securities making up the index the problem is of a greater magnitude. Luoma et al. (LMPP) (1994) note that on a thin market, one of the main sources of beta bias is nontrading. Their finding is that the "degree of thinness (number of nontrading days and dependency in the security's current and lagged prices) ...seems to be an important factor affecting the applicability of different beta adjustments." Lo and MacKinlay (1990) recognize this and explicitly treat for it in their model of nonsynchronous asset prices by setting the times between trades as a stochastic variable. Previous studies by Scholes and Williams (1977) and CMSW (1986) fixed the nontrading period.

VI. D. Correcting the Biases in Estimating Systematic Risk

Jokivuolle (1995, p. 455) states that "... the problem of assessing the true stock index value when some constituent stocks of the index do not trade in every period is encountered in many finance applications." In the literature, corrective methods have been applied to the market model estimate of beta and to the observed index, though relatively little work has been done on the latter. Authors such as Scholes and Williams (1977) and Dimson (1979) have estimated beta to account for the factors causing the biases. Others such as Joukivoule (1995), Harris (1989), and Blume, MacKinlay and Terker (1989) have attempted to estimate the true market index, corrected for the problem of non-trading (or nonsynchronous trading). Since the beta-correction methods are well known[1] I will not discuss them further but will instead briefly review the index-correction methods.

Blume, MacKinlay, and Terker (1989) estimate an index based only on the transaction prices or the bid-ask quotes of traded stocks in a situation where price movement seems to be caused more by overall market changes rather than by firm specific information.

Harris (1989) constructs an index that use the transaction history of all constituent stocks. The transaction history of those stocks which trade is used to estimate a set of

[1] A short list of studies that have considered different aspects of this problem are: Atchison, Butler, and Simonds (1987), Berglund, Liljeblom, and Loflond (1989), Eubank and Zumwalt (1979), Fowler and Rorke (1983), Fowler, Rorke, and Jog (1985), Hawawini and Michel (1979), Hawawini, Michel, and Corhay (1985), Lo and MacKinlay (1990), Luoma, Martikainen, Perttunen, Pynnonen (1994), McInish and Wood (1985, 1986), and Perry (1985), Silber (1975).

prices for non-trading stocks. These prices are imputed to be what the actual prices would have been had there been a transaction in the stocks that did not trade.

Stoll and Whaley (1990) develop an autoregressive-moving average (ARMA) (p, q) model to capture the joint effects of thin trading and the bid-ask spread on the observed index returns. The deviations from the estimated model, i.e., the return innovations, are then used to proxy the true index returns. To account for infrequent trading they assume that the stocks trade at least once every *n* periods (a condition generalized in Lo and MacKinlay (1990)). Observed returns are treated as a weighted average of current and lagged returns. The weighting factor depends on the relative number of traded stocks in the index and on their proportion of total market value.

Jokivuolle (1995) adapted this model to allow for cointegration between the true and observed indices. He obtains an infinite moving average (MA) process for the observed index which is decomposed into a permanent (random walk) and a cyclical (stationary) component. The observed index is estimated by the log of a finite autoregressive integrated moving average (ARIMA) process whose permanent component represents the log of the true, unobserved index.

VII. Selecting an Index

VII. A. Introduction

In the empirical analyses to be completed in this thesis I will be using several indices, which although almost all value-weighted, are not necessarily similarly constructed. In view of this I will discuss some issues about the selection of an index, the purposes of an index, and the different types of indices that are in general use. In Appendix D I outline the methodology employed in constructing the indices of the ADRs and their underlying stocks used in this thesis.

VII. B. Features of a Good Index

Indices are usually constructed as a means of evaluating a portfolio of assets. They may be useful to the investor or investment manager in aiding her investment strategy by providing her with a benchmark against which she measures her performance. For instance, there are several publicly available index funds that have as their primary objective the tracking of one index or the other. Whereas it is quite simple to track the movement of a single asset over time, the same cannot be said of large portfolios.

Investors have found other uses for international indices such as the basis for asset allocation, "backtesting" of investment strategies, and in the trading of derivatives. Funds may be allocated to certain markets on the basis of that country's weight in a global index, for instance. Backtesting may be done to discern how a strategy would have worked over some past period, notwithstanding the fact that past performance need not represent the future even though it may be used as an input in forecasting returns. There is a growing demand for index options and futures in the international equities markets arising partly from the relatively low transaction costs involved. An equity index with the demonstrated capacity to track the overall movements in the broad market is a prerequisite for successfully engaging in this type of investment in order to benefit from the concomitant hedging and leveraging possibilities. Closely affiliated with this practice is 'portfolio trading' where whole indices are sold in the form of a single block of stocks. The benefits include lower transaction costs, the allocation of larger tranches of funds with less price impact, and less management personnel is required.

The well-constructed index should exemplify two main features. The first is that it should be reflective of the market as a whole, and the other is that the constituent stocks are available to all investors, local and foreign. In the case of foreign investors the latter is even more crucial. In fact, agencies like the IFC and investment firms like Morgan Stanley Capital International (MSCI) take cognizance of this latter point by constructing multiple indices, at least one of which takes into consideration the extent to which the market is "investable"; i.e., whether or not foreign investors can actually own the constituent stocks. These two aims may result in a tradeoff as a market may be well represented by stocks that have foreign or other ownership restrictions. To obtain coverage of the stock market, selection is usually based on the inclusion of the larger, liquid stocks that are leading indicators of the market place. Additionally, the index should host leading stocks from a wide cross section of sectors in the economy, including a number of stocks from the small, medium, and large firms.

The effort of balancing these objectives could give rise to the negative effects of overrepresentation by tightly-held stocks (with low floats) and small, illiquid stocks with higher-than-normal volatility. Domowitz, Glen, and Madhaven (1997) cite evidence of this in Mexico. Also, this is the case, for instance, of the index of the Jamaican Stock Exchange, which includes all listed stocks. There is evidence that the float is small (represented by low turnover to market value) and that the majority of the best stocks are tightly held by a few institutions and high-net-worth individuals (Hunter (1993), Kitchen (1986)). A further complication that arises from the inclusion of too many stocks in an index, is the impact of cross ownership of companies. If substantial cross ownership exists, then there will be double counting in the index. The index may not display sufficient resilience[2] as the impact of news may cause a downward trend in the prices of companies related through management, strategy, output, etc. Finally, fund managers may find it more expensive to create their own proxies of indices that have too many constituents.

The second important feature of the index is the extent to which it is investable, not only for residents, but also for foreign investors. This is important especially in a context where there are still vestiges of barriers to international investment and restrictions on some types of shares or sectors within even developed markets. Indeed,

[2] Resilience is the ability of the market to recover from shocks within a reasonable time. For this to take place it requires, inter alia, depth (thick trading), breadth (stocks from a cross section of industries), and investor confidence.

only recently did Norway, Sweden, Finland, and Switzerland remove the latter restrictions (Carter (1995)). There are still several restrictions in Thailand, Chile, Korea, Mexico, and other emerging markets despite their continued efforts at liberalization. The existence of restrictions impact on the construction of an index in that any effort to create an investable index might lead to one that does not adequately reflect the performance of the market since important stocks may be excluded. An index that does not indicate the extent to which a market allows foreign investors to buy into it will be misleading in its performance. This is the essence of the argument by Bekaert and Urias (1995), for instance, that using the indices of the emerging markets to investigate the diversification benefits that may be available could lead to erroneous conclusions for foreign investors.

VII. C. Types of Indices

An index is normally an arithmetic average[3] of the price performance of its component stocks. Each stock impacts on the index in a manner that is a function of the price, the 'weighting' of the stock in the index, and in the case of the value-weighted index, also the number of shares in issue. The major difference between indices is in the method used to weight each constituent stock.

Market-value weighted index. This method weights each stock in the index by the market capitalization of the stock (i.e., the product of each stock price and the number

[3] The prices (in the case of price-weighted indices) and the market values (in the case of value-weighted indices) are summed and then divided by a divisor to estimate performance. The geometric average is the product of (1+ return on asset i, R_i) for all asset i in the (price-weighted) index.

of its outstanding shares divided by the sum of the market capitalization of all stocks in the index). It is the most popular, and arguably the best, means of forming an index. This method results in an index that is affected by the component stocks in proportion to their market values; that is, larger stocks have more impact than smaller stocks. This is consistent with portfolio theory in that it reflects the market portfolio - the aggregation of the equilibrium demand and supply of assets of all investors in the market - more closely. The return on this index represents the gain by an investor who holds a *portfolio of all the assets in the index in proportion to their market values.* The value-weighted index, therefore, provides the return that a 'buy-and-hold' investment strategy provides, if the portfolio is weighted by market values and there are no new issues, de-listings, or mergers. In other words, the value-weighted index and the portfolio of all the stocks in the index weighted by their market values, are perfectly correlated. In fact, this perfect tracking of the value-weighted index provides the raison d'être of index funds. The S&P 500 is a value-weighted index.

While this method has several advantages, it suffers from the fact that value-weighting assumes that all the stocks of a firm are freely traded. An alternative, the *free-float weighted index* uses only that portion of stocks that are investable. This latter means of averaging can be biased by frequent changes in the float if current information on ownership structure is available only with a lag. Free-float weighted indices are also not comparable across markets, and it may be more difficult to rebalance portfolios that track them since the index and the portfolio can move out of synchronization with time.

Price-weighted average. A price-weighted index simply averages the *prices* of the stocks in the index, making a return on the index equivalent to the relative change in the average price. The return on a portfolio made up of *one share of each firm* in the index measures the return on the price-weighted index. The market value of such a portfolio is the *sum* of the prices of the stocks, whereas the index is the *average* of the prices of the stocks; thus an x percent return on the portfolio is an x percent return on the index. This index also reflects the return on a buy-and-hold portfolio made up of an equal number of shares of each firm in the index (the funds invested in each stock is proportional to the stock price). A leading example of such an index is the Dow Jones Industrial Average (DJIA).

Equally-weighted index. This index takes an average of the *returns* on the stocks in the index (i.e., the averaging method equally weights each return). This corresponds to an investment strategy of *buying the same dollar value of stocks of each firm* (as opposed to the same number of stocks per firm in the price-weighted index or a per-firm investment in proportion to market value in the value-weighted index). Investing in this portfolio is not a buy-and-hold strategy. Consider the investor who starts out with equal dollar investments in two stocks. If at the end of the period one stock doubles in price while the other experiences no change, then the portfolio is now heavily invested in the stock that has the increase in price. That is, as relative prices change, the portfolio becomes unbalanced in favor of stocks with increased prices. To maintain an equally-weighted portfolio requires selling some of the stock with the increased price and/or acquiring more of the other stock. Tracking the equally-weighted index requires active-portfolio management.

Hedged vs unhedged indices. Another important consideration in selecting an index is whether the index currency-hedges or not. A US investor who takes a position in the Mexican market, for instance, may use a peso index (e.g., the IPC) as a benchmark. This is as if the investor is concerned only with the (peso) price performance of the stocks in her portfolio while being neutral to the exchange rate effect. However, the return on such a portfolio is made up of stock price returns and exchange rate changes. The *unhedged index* considers the investor's exposure to the volatility of the foreign exchange market and converts the local (peso) index into the dollar equivalent at the daily spot rate of exchange. An example of this is the Datastream (Dollar) index. *Hedged indices*, on the other hand, incorporate a currency hedge usually based on the forward (30-day selling) rate of the foreign currency.

Chapter 3. Definition and Tests of Integration

I. Definition

Market integration underpins many important practical and theoretical issues in finance. Thus, from both a practical and a theoretical standpoint it is important to define what constitutes "integrated markets". A frequently-used definition is that markets are completely integrated if assets with perfectly correlated returns have the same price in a given currency regardless of the market within which they trade. Equivalently, if two assets have identical risks, then they should be priced to yield the same *expected* returns. Segmentation exists, therefore, if "... two assets which belong to different countries but have the same risk with respect to some model of international asset pricing without barriers to international investment have different expected excess returns." (Stulz (1981a)).

One important implication of this definition of integration is that, if two markets are integrated, then the price of risk for each priced risk factor is the same in each market. This condition should hold not only on average, but also from period to period. State a one-factor conditional asset pricing model with time-varying price of risk as:

$$E(r_{it} | \Omega_{t-1}) = \varphi_{t-1} \mathrm{cov}(r_{it}, r_{mt} | \Omega_{t-1}) \qquad (3.1)$$

where r_{it} is the return on asset i, Ω_{t-1} is the information set used by the investor to make her decisions, φ_{t-1} is the time-varying price of risk dependent on a vector of information variables including a constant, and *cov*(.) is the (quantity of) risk of asset *i* where r_{mt} is the return on the market. The model elucidates the first definition. If the risks of two assets *i* and *j* are equal, then it follows immediately that their expected returns are also equal, since the price of risk, φ_{t-1}, is the same for all assets. The second definition holds simply because perfectly correlated returns imply perfectly correlated prices since return is simply a linear transformation of prices.

This notion of integration is also employed by Webb, Officer, and Boyd (1995), Bekaert and Harvey (1994), Harvey (1994a), Gultekin, Gultekin, and Penati (1989), Wheatley (1988), Campbell and Hamao (1992), Bosner-Neal, Braur, Neal, and Wheatley (1990), Jorion and Schwartz (1986), Errunza and Losq (1985a), among others[4].

Other less precise definitions, hence, less powerful tests of integration, are frequently encountered in the literature. At least two authors have taken issue with the several existing definitions (and by extension, with the tests of integration). Adler and Dumas (1983) are concerned that there are no precise definitions nor definitive means of testing the extent of integration. Recently, Chen and Knez (1995) have restated this concern by pointing out that two of the used definitions are not particularly helpful in the development of a model which measures integration. These are that "...integrated

[4] Multi-factor asset pricing models such as the APT have been used as a benchmark to measure risk across markets since asset returns may be related to a small number of numeraire-invariant common factors. Hence, the APT holds without the assumptions of strict purchasing power parity (PPP) (e.g., Grauer, Litzenberger, and Stehle (1976)), logarithmic utility functions (Adler and Dumas, (1983)), or zero correlation between exchange rate and stock returns (e.g., Solnik (1974b)), as required with single index measures of risk such as the international CAPM. (See Solnik (1983) for proof and Gultekin et al. (1989) for more on this). Cho, Eun, and Senbet (1986), Gultekin et al. (1989), Korajczyk and Viallet (1989), Korajczyk (1995), and others employ multi-factor models. Naranjo and Protopapadakis (1996) develop a benchmark model of market integration using this definition.

markets should fluctuate together..." -display high co-movements in their returns- and that "...integrated national markets should imply highly correlated consumption rates...". The former is not adequate since even stocks on the same market do not necessarily move together (Adler and Dumas (1983), Errunza (1994)). In the case of the latter, the dependence on a parametric asset pricing model (the consumption CAPM (CCAPM)) pushes the test into the realm of the joint hypothesis. The joint-hypothesis problem results from the fact that a test of integration jointly tests the appropriateness of the asset pricing model in describing the data and whether or not the markets are integrated. So a rejection of integration is not definitive support for segmentation but could reflect problems related to the underlying model (see Roll (1977) for a discussion of the joint hypothesis in the context of testing the efficiency of a market, or Jorion and Schwartz (1986), Wheatley (1988), Bosner-Neal et al. (1990), and Mittoo (1992)) in the context of testing integration.

Since most tests of market integration employ an asset pricing model, it is not surprising that there are mixed results (see below). Stulz (1994) states that using asset pricing models to test for barriers to international investment "typically lacks power." However, one advantage of using asset pricing models to test for integration is that asset returns (or prices) are able to capture the impacts of effective barriers to international investments regardless of the type of barriers. Hence, if barriers such as limits on foreign ownership of firms are imposed but are not binding, then the asset prices will reflect the ineffectiveness of the barriers, whereas an attempt to explicitly model the barrier may lead to misleading conclusions if they exist but are not effective. Market integration has several economic implications (considered below) for many areas of finance such as options valuation, capital budgeting, cost of capital, and international portfolio diversification.

II. Some Tests of Market Integration

Adler and Dumas (1983, p. 967) state that "...there is as yet no definitive empirical method for determining whether and to what extent the international capital market is segmented..." They suggest four lines of investigation.

The first interprets low correlations between national markets as evidence of segmentation. This they assert is "...misguided..." The notion that integrated markets should necessarily fluctuate together is fraught with difficulties given that random local factors such as political problems and disasters may affect a single country and not another. Furthermore, if a given country's market is heavily influenced by a particular sector/industry there may be industry-specific random factors which affect one country and not others. Hence, while integrated markets may have high levels of price co-movements, the absence of co-movement does not necessarily suggest that the markets are segmented. Bekaert (1995) uses the correlation between conditional returns, where the conditioning instruments are a common set of global instruments, to test for integration.

Another approach is to assess the correlation between national consumption rates. The argument is that if investors are free to trade risks and acquire insurance across borders (i.e., if integration exists), then the allocation of risk bearing (the primary function of capital markets) is Pareto optimal. The result is that consumption risks can be so allocated to achieve optimality for all investors (risks are *mutualized*). Individual consumption risks can be eliminated in this manner, leaving individual consumption a function of aggregate consumption - individuals bear only the social (aggregative) risk. This can be generalized across all individuals in a particular economy where aggregate consumption is the world (aggregate) consumption. This being the case, in an intertemporal framework it is clear that stochastic, unanticipated variation in the national rate of consumption will be perfectly correlated with the random changes in the aggregate (world) consumption rate. Different versions of this consumption-based CAPM have been proposed by Stulz (1981a), Wheatley (1988), Cumby (1990), and others.

A third method uses security prices in models which capture segmentation and integration, respectively. By applying these models to the data and selecting the model which best explains the data we can make inferences about the existence of market integration. Within this framework we can fit models such as the Arbitrage Pricing Theory (APT) with common factors across national stock markets and see if the factors are similarly priced in each of them. Stehle (1977) and Stulz (1981b) take this approach.

A final approach is to employ the CAPM framework without taking any of the polar positions on integration but to assume a continuum which is captured in the model. Previous work which apply a proportional tax on overseas investment or which models the effect of a limit on foreign ownership of domestic firms may be seen in this light (e.g., Black (1974), Stulz (1981a), Errunza and Losq (1985a), Eun and Janakiramanan (1986)).

However, two general approaches to investigating international capital market integration characterize the literature. The *one* is to assume that markets are fully integrated and apply an international asset pricing model which is consistent with the existence of full integration. For instance, Cho, Eun, and Senbet (1986), Gultekin et al. (1989), Harvey (1991), and Campbell and Hamao (1992), Korajczyk (1995), and Naranjo and Protopapadakis (1996) use the latent variable/multi-factor/international APT-type tests, Jorion and Schwartz (1986) and Mittoo (1992) apply CAPM-type tests, and Wheatley (1988) and Cumby (1990) use the Consumption CAPM (CCAPM). The *other* assumes that markets are segmented and models the observed market-segmenting barriers and incorporates their effects on equilibrium returns and portfolio holdings. The barriers are usually represented by taxes on foreign portfolio investments (e.g., Black (1974), Stulz (1981b)), by placing limits on the level of foreign ownership in a particular market (e.g., Eun and Janakiramanan (1986), Hietala (1989), Alford and Folks (1996)), or by other restrictions such as "outward" and "inward" costs of investing overseas (e.g., Cooper and Kaplanis (1994a)).

However, Errunza and Losq (1985a) and Errunza, Losq, and Padmanabhan (1992), include the "mild segmentation" test in order to reflect the notion that markets are usually never fully integrated nor completely segmented.

There are tests of integration which are not based on these structured asset pricing models. Ammer and Mei (1996) employ the approximate present value model to decompose the return innovations on different markets into innovations on the future expected return, dividend growth rates, interest rates, and exchange rates. They then use the correlation between the innovations in future expected stock returns of different countries to make inferences about financial integration. Chen and Knez (1995) use the pricing kernel to develop two measures of integration based, respectively, on the law of one price (LOP) and on the absence of arbitrage between integrated markets. Both models rely on the fundamental asset pricing theorem (see below). Several others have used event-studies to make inferences about the level of integration of a market with the international capital markets. The event of interest is either a major policy change affecting the market's equilibrium risk and return, (e.g., Bosner-Neal et al. (1990)), or the cross-listing of assets on a foreign stock market (e.g., Sundaram and Logue (1996)). Similarly, tests of cointegration between a national market and the world market have also been used to make inferences about integration (e.g., Arshanapalli and Doukas (1993)).

Recently, Bekaert and Harvey (1994) test for integration of the emerging markets by using a conditional (time-varying) model of integration to account for increasing liberalization in these markets. Returns on a national index are conditioned on their covariance with the world market portfolio, the measure of risk in integrated markets, and on the variance of the local index which measures country risk in segmented markets. The measure of integration changes over time and reflects the relative weights of these two risk measures. This is a regime-switching measure which allows the market to become integrated after being segmented, but also to reverse direction and to become segmented after being in a state of integration. Furthermore, an implicit assumption of the model is that once the market is in a particular regime there is no additional demand for assets to be used as a hedge against a possible regime shift, which would require the specification of several priced factors or hedge portfolios (see, e.g., Merton (1973) for the impact of these hedging portfolios on the asset pricing model).

Korajczyk (1995) assumes that markets are integrated and that there are a small set of risk factors common to the majority of stocks that are priced internationally. He estimates these factors with the asymptotic principal component analysis. The factors are then used in the IAPT to measure risk and estimate equilibrium returns. A regression of excess returns for each security on these factors and their associated price of risk (jointly, the excess returns on factor-mimicking portfolios) should have an intercept of zero if markets are integrated and if the IAPT adequately describes the return-generating process of the assets. The absolute size of the deviation from zero (after correction for biases, etc.), called the *average adjusted mispricing*, indicates the level of market integration. Levine and Zervos (1996) also use this approach to test the hypothesis that markets become more integrated after governments introduce market-liberalization policies.

Bekaert (1995) employs three measures to test integration of the emerging markets. In the first, he tests the predictability of asset returns using a set of local and global (US) predictor variables. If the predictability of excess returns reflects time-variation in the prices of risk, then examining predictability in an emerging market using variables observed to predict the returns of industrialized integrated markets will provide an insight into integration, since in integrated markets the prices of risk are the same across markets. If the local variables do not predict the excess returns of the national market, then this is seen as an indication of integration. Similarly, if the global variables predict local returns, then that too supports integration.

Bekaert's second test of integration is based on the correlation between the *expected* returns of the emerging markets and the US, where the expected returns are generated using the above-mentioned predictor variables. He argues that if markets were perfectly integrated, if there were only one risk factor, and if the exposure to that factor (beta) were constant, then the expected returns to all markets would be perfectly correlated. Intuitively, consider the model $E(r_{it} | \Omega_{t-1}) = \beta_i [E(r_{mt} | \Omega_{t-1})] \ \forall i$, where the usual definitions hold but m is the world market and β is constant. Since [.] is common to all stocks/markets in the integrated world and beta is constant, then [.] explains all the variation in r_{it} and in r_{jt} also, thus causing perfect correlation between i and j.

In a multi-factor model there could be cross-market variations in exposure to the different factors; e.g., one country responding more to shocks in, say, oil prices and another to shocks in the prices of agricultural commodities, which would confound the test. Tests using correlation lack power since, even if highly correlated returns (reflecting the common component in the respective returns) suggest integrated markets, the lack of material correlation between the returns need not indicate segmentation (e.g., Adler and Dumas (1983)).

In a third test Bekaert first finds the incremental variation caused (only) by the local predictor instruments in a multiple regression of each market excess return on the world index (global factor) and the local variables. He then finds the variation with the model containing only the local instruments. The ratio of the first to the second is his measure of integration, where the higher the ratio the more segmented is the market. This test overcomes the weakness in the second method where the correlation between the expected returns may be affected by the lack of predictability of some markets.

Chen and Knez (1995) commence with the commonly accepted idea that "...two markets cannot be integrated...if it is possible to construct two portfolios, one from each market, that have identical payoffs but different prices" (since prices are equal to discounted payoffs, and if markets are integrated, then the discount factors are equal). This is similar to the definition of Stulz (1981a) but Chen and Knez extend it to include the condition that the law of one price (LOP) must hold between the portfolios if there is to be perfect integration. This being the case, it is of interest to consider the relations between the "pricing structures" of the markets under question, which are "summarised" by the "implied pricing functionals". The latter, under certain conditions, may be represented uniquely by a "stochastic discount factor"[5].

[5] The stochastic discount factor (also called a pricing kernel, pricing operator, or the inter-temporal marginal rate of substitution (IMRS)) underlies the canonical conditional asset pricing model: $E[p_t] = E[(\pi_{t+1} d_{t+1}) | \Omega_t]$, or $E[\pi_{t+1}(R_{t+1}+1)|\Omega_t] = \iota$, where $(1+R_{t+1}) = (d_{t+1}/p_t)$ and (d_{t+1}) are vectors of asset returns and payoffs, respectively, E is the expectation operator, ι is the unit vector, Ω_t is the current information set, p_t is a vector of asset prices, and π_{t+1} *is the stochastic discount factor.* Different asset

Market integration can then be measured by determining if two markets have at least one common stochastic discount factor. The minimum distance between the two sets of stochastic discount factors is a measure of integration. *Weak-form* integration is the condition in which the stochastic discount factors overlap; i.e., the distance between them is zero so there is no pricing difference between the markets. Weak-form integration, however, does not rule out the existence of arbitrage opportunities. *Strong-form* integration exists when there is the total absence of arbitrage between the prices of the two portfolios with the common payoffs. Weak-form integration then is a necessary but not a sufficient condition for the existence of perfect integration.

This contribution by Chen and Knez to tests of integration poses an interesting scenario. Given that most previous attempts are confounded by the joint-hypothesis problem and that their results are mixed, what then should be our conclusion with regard to market integration?[6] Chen and Knez discuss some of the previous tests in light of theirs. Two tests come to mind: those using mean-variance spanning (see Chapter 5 for details on mean-variance spanning) and tests using cointegration to

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pricing models imply different discount factors. In the case of the CAPM, π is a linear function of the market portfolio and the risk-free asset; π is the IMRS and a function of the growth rate of aggregate consumption under the Consumption CAPM. The Intertemporal CAPM can be restricted so that π is a nonlinear function of the return on aggregate wealth and other hedging portfolios. Note that models with linear pricing kernels cannot adequately price assets such as derivatives which have payoffs that are nonlinear in priced risk factors (Bansal, Hsieh, and Viswanathan (1993)). In multi-factor models, π can be a linear function of pre-specified (and estimated) factors. See De Santis (1994, 1995), Bekaert and Urias (1995), Ferson (1995), Hansen and Jagannathan (1991), and Snow (1991) for more details.

[6] Segmentation has been detected by models which test the joint hypothesis even between the most unlikely of markets, e.g., Canada and the US (Mittoo (1992)) for periods 1977 to 1981 and for full period 1977 to 1986 for Canadian non-interlisted firms. See also Jorion and Schwartz (1986). Foerster and Karolyi (1993) discuss some factors promoting integration, which are generally present between these two markets. Naranjo and Protopapadakis (1996) find that their multi-factor asset pricing model frequently rejects the hypothesis of integration between NYSE, AMEX, and NASDAQ. They note that the success of their test is fundamentally related to the factors being priced in each market but that the factors are not endogenously selected. Hence, I think it is likely that rejection of integration results partly from rejection of the specific model that is estimated.

examine equilibrium relations between closed-end country funds and their underlying prices. The former is used by Bekaert and Urias (1995) where the duality between Hansen-Jagannathan (H-J) (1991) bounds and mean-standard deviation frontiers are used to investigate if the stock portfolios of developed markets span the returns of emerging markets country funds. The test of integration is developed from the fundamental asset pricing model based on the stochastic discount factor that prices the returns on assets and from the fact that the country fund essentially is a single asset trading in two markets. Specifically, in segmented markets the stochastic discount factor that prices the country funds is different from that which prices their underlying stocks. The two different stochastic discount factors are used to estimate the respective expected returns on the two assets. The difference between these two expected returns will be significant in segmented markets and this difference represents the amount of return that an investor from a developed market would be willing to forego in order to have barrier-free access to the restricted emerging market.

Chen and Knez assert that these tests "...are not tests of market integration or cross-market arbitrage..." The H-J frontiers may not intersect (overlap) even for two perfectly integrated markets since any observed frontier is formed from only a subset of all the admissible discount factors which characterize the assets in the respective markets. In other words, that there is no overlapping of the frontiers of two sets of assets (markets) may be reflecting the fact that the specific discount factors which generate those specific frontiers are not representative of the entire set of possible discount factors. This then is synonymous with the joint-hypothesis problem mentioned earlier. That is, rejection of the hypothesis of integrated markets could mean that the markets are not integrated, or that the stochastic discount factors (pricing kernels) reflected in the H-J frontiers are not representative of the entire universe of discount factors, thus driving the observed segmentation, or both. Therefore, mean-variance spanning tests of integration do not avoid the basic problems that plague the tests based on asset pricing models.

The recent developments in time-series econometrics has led to a new test of market integration; that of cointegration between the returns (prices) of two or more assets with the same risk (expected payoffs). Two securities which readily lend themselves to this type of analysis are country funds and depositary receipts. Both of these assets derive their values primarily from the underlying stocks. In integrated markets, the prices of the derivative assets and of the underlying stocks are cointegrated. This test has been applied to country funds by Chang, Eun, and Kolodny (1995). They state that it is possible to "...test if the (US) capital market and the capital market of a closed-end country fund home country are bilaterally integrated by testing whether the share value and its Net Asset Value (NAV) are cointegrated." This they argue overcomes the usual pitfall involving the joint-hypothesis problem which arises in tests of capital market integration.

The underlying logic of this argument is that if the markets are integrated, then arbitrage between them will cause the country fund (or the ADR) in one (host) market to be a mere substitute for the underlying in the other (home) market, linked by a "cross-border equilibrium relation". Arshanapalli and Doukas (1993) found cointegrating relations between the indices of the three major European markets and the US and interpreted this as strong "interdependence" and "...cross-market efficiency in the sense that these markets do not drift far apart...". There was no cointegrating relation between Japan and the others, thus this "market is not integrated with..." the others (p.203).

The Chen and Knez (1995) weak-form integration where the law of one price (LOP) holds "...presents the most general requirement for a well-functioning capital market; it does not rule out the violation of some other minimum condition for any market equilibrium. For instance, even when the LOP holds, some positive payoffs may have negative or zero prices," thus allowing arbitrage (p.292). Furthermore, the "absence of arbitrage implies the LOP, but not vice versa" (p.293). By this logic one can only conclude that, at best, the test of integration using a cointegrating relation between country funds or ADRs and their underlying assets, satisfies only one condition under the Chen and Knez framework - that of weak-form integration where the LOP holds. In other words, the presence of a cointegrating relation does not rule out arbitrage possibilities[7]. In fact, since cointegration is a long-run phenomenon, it is possible that at any point in time the law of one price could be violated but that cointegration holds on average. Whether or not arbitrage profits are possible, in the presence of cointegrating equilibrium relations, is an empirical question which will not be

[7] In integrated markets, arbitrage possibilities cannot persist as the profit potential will attract arbitrageurs who would quickly drive prices to be equal. Arising from the existence of barriers between markets, this arbitrage condition might not be eliminated immediately (Adler and Dumas (1983, p. 932). However, given the lure of gains, over time we should assume that the market will react appropriately. It may be for this reason that Alexander et al. (1987, p. 155) note that dual listing produces an "externality effect" of indirectly integrating the market for pure domestic securities with the foreign securities market. Diwan et al. (1992) argue that there should be no impediment in the way of domestic investors to hinder them from arbitraging between the underlying stocks and the country funds as such action increases the price of the domestic asset to match that in the foreign market.

considered in this thesis. From the Chen and Knez proposition it is easier for two smaller markets to show perfect integration than for two large ones, since an increase in the number of assets will attenuate the pricing consistency across assets. Thus, if weak-form integration between two markets is rejected using country funds or ADRs which are a (small) subset of the markets, then it will be rejected if the entire markets are used.

Event studies are an additional means by which non-asset-pricing tests are employed to make inferences about integration. They exploit the implications for asset pricing and risk of announced changes or actions which serve to overcome segmentation. In particular, the event study methodology has been employed to assess the impact on the prices of underlying stocks of announced or actual dual listing and of the effect on country funds' premium (price less net asset value) when announcements about market liberalization are made[8]. The logic of these tests is that if a firm operates in a segmented capital market, then it experiences a reduction in its cost of capital (expected return on the stock) or an increase in its share price if it takes actions to overcome segmentation. One such means of mitigating the effects of segmentation is to list on an overseas exchange in a larger market that is integrated with the international capital market. On the announcement and/or listing, the firm's price will reflect investors' belief about a new equilibrium pricing relation. Any increase (reduction) in the price of the stock (expected return or cost of capital) suggests that the listing market is segmented from the host market.

[8] Fama (1991, p. 1577), in the context of tests of market efficiency and equilibrium asset pricing notes that event studies come the closest to avoiding the joint hypothesis.

This method is not exempt from shortcomings. Generally, every event study faces the problem of changes being generated by events unrelated to the event of interest but which could affect the expected results. In some cases, the study can be conducted to minimize this effect, but this is not always possible. For instance, in an event study to examine the impact on risk of international listings of US stocks, Howe et al. (1993) use the implied standard deviation (ex ante measure of future volatility) from the exchange-traded options of the underlying stocks of the depositary receipt in lieu of the ex post, realized variances. By so doing they avoid contamination of their results by unanticipated events unrelated to the cross-listing. Any event occurring subsequent to the listing and within the event window, even though unrelated to the cross-listing, would be a part of the ex post volatility. By using ex ante volatility formed in the pre-event period the post-event occurrences have no contaminating effects as the market would not have included them in their implied volatility.

Recently Ammer and Mei (1996) applied the approximate present value method of asset valuation to stock market returns and inferred the extent of financial (and economic) integration between markets. The essence of the model is to use the present-value method of asset pricing to decompose the innovations to excess returns into innovations about future excess returns, future expected dividend growth rates, future interest rates, and future exchange rates (e.g., Campbell and Ammer (1993), Campbell (1991)). Financial integration between two markets is then inferred from the magnitude of the correlation between the future expected excess stock returns of the countries. Intuitively, if the returns in integrated markets are being driven by common international risk factors, then any change in the prices of risks will affect the conditional returns of the stocks in both markets. Assuming that factor loadings (or betas) are constant or that they contribute less to the time variation in expected returns than do the prices of risks (this has been suggested, e.g., Ferson and Harvey (1991)), then changes in the prices of risks will lead to highly correlated changes in future expected excess returns between stocks in the markets of the different countries.

Additionally, the strength of the correlation between the dividend innovations of the countries in question indicates the extent of *economic* integration. This arises from the fact that in the presence of economic integration, barriers to labor and capital mobility are low, as are the differences in technology and cost of production. The common economy-wide factors driving economic growth would, therefore, have the same impact on the cash flows of firms in the economies, thus similarly affecting dividends. The Ammer and Mei method of testing for integration between markets relies on the fundamental asset pricing model to decompose the innovations of the excess returns. However, as this model has less structure than, say, the CAPM or the APT, tests of integration based on the present value method are likely to be more robust to the joint hypothesis problem.

Alford and Folks (1996) develop a dimension-free coefficient of integration from the ratio of the excess return per unit of covariance risk of a stock (national market) to the excess return per unit of variance risk of the market (world market) portfolio (by decomposing the CAPM). They point out the consistency between the various tests of market integration which assume that the market is segmented and then directly model the impact of the barriers on equilibrium returns and portfolio holdings. The first set of tests apply taxes and proportional transaction costs which reduce the foreign investors' returns and change her optimal portfolio and the coefficients of her (investment) objective function, while at the same time affecting the supply and demand for assets. This is the approach taken first by Black (1974) and then by Stulz (1981b). In the second approach, Errunza and Losq (1985a) capture the effect of segmentation by imposing foreign ownership restrictions, which is then generalized by Eun and Janakiramanan (1986). Alford and Folks note that the difference between these two methods is purely semantic as the first resembles a tariff while the other is a quota. In international trade both achieve the same objective.

Alford and Folks impose ownership restrictions on investors taking either long or short positions in securities outside the country of their residence. Moreover, the restriction is general enough to apply to domestic investors who are subjected to outward investment limits imposed by their governments. This differentiates their approach from the previously-discussed models and is consistent with the approach of Cooper and Kaplanis (1994a, b). The (investment) objective function of the investor mirrors these restrictions on her optimal portfolio weights.

Essentially, through the process of constrained optimization the authors arrive at a "segmented" version of the CAPM from which they specify the excess return on the market portfolio of the *i*th country, r_i, weighted by the inverse of its covariance with the world market portfolio, σ_{im}, as a function of the product of the excess return on the world market, r_m, and the coefficient of integration γ_i, weighted by the inverse of the variance of the world market returns: $\frac{r_i}{\sigma_{im}} = \frac{r_m}{\sigma_m^2}\gamma_i$. In the case of full integration, γ is equal to one. The underlying idea of this test is the fact that in segmented markets the return per unit of risk differs between markets. The model is tested with a non-parametric statistic and captures the time-variation in integration between markets. While this model has some attractive features, the fact that in the case of integration it collapses to the CAPM subjects it to the joint-hypothesis problem in the case where integration is rejected. One could not tell if markets are indeed segmented, if the CAPM does not represent the return generating process of the market, or both.

(Other tests of integration are discussed elsewhere in the thesis as are appropriate. Several indirect tests based on the examination of the impact of particular events on risk and returns are mentioned but are not described in detail.)

III. Integration of the Emerging Markets: Empirical Results

This section summarizes some of the empirical results of studies that have tested the extent of integration of the emerging markets with the world capital market. Table 3.1 lists the authors, type of tests, and results for developed and emerging markets. While there have been many studies to ascertain the extent of market integration between the developed markets[9], it is only recently that, with the availability of new data sets,

[9] A non-exhaustive list of direct and indirect tests of integration of developed markets include: Alford and Folks (1996), Sundaram and Logue (1996), Webb et al. (1995), King et al. (1994), Lau et al. (1994), Arshanapalli and Doukas (1993), Foerster and Karolyi (1993), Howe et al. (1993), Jayaraman et al. (1993), Campbell and Hamao (1992), Mittoo (1992), Marr et al. (1991), Cumby (1990), Howe and Madura (1990), Jeon and von Furstenberg (1990), Gultekin et al. (1989), Hietala (1989), Wheatley (1988), Alexander et al. (1988), Jorion and Schwartz (1986), Stehle (1977), and Solnik (1974a).

attention has been shifting to the more esoteric markets of the lesser developed countries. Some papers using emerging markets data as the subject of study include the following: Bekaert (1995), Bekaert and Urias (1995), Bekaert and Harvey (1995), Harvey (1994), Korajczyk (1995), Bosner-Neal et al. (1990), Chang et al. (1995), Errunza, Losq, and Padmanabahn (1992), and Errunza and Losq (1985a). Various methodologies are employed in these studies and there is no consensus in the results.

Bekaert and Urias (1995) use a sample of emerging market country funds to investigate the extent of diversification benefits and market integration over the period 1986 to 1993. Applying the mean-variance spanning technique and, in particular, a measure which indicates the premium in terms of expected returns that an investor would pay for the opportunity to have direct access to a closed market, they find that Indonesia, Taiwan, and Thailand, but not Korea, Philippines, or Turkey, are segmented from the US and the UK.

Chang et al. (1995) conduct tests with similar objectives using 15 funds over the period 1985 to 1990. Country funds that are traded in the US are found to behave more like US securities. One interpretation of this is that there is a significant level of integration of their home markets with the US. However, as the underlying stocks are influenced more by their home markets, there is no clear-cut conclusion that can be drawn about the degree of integration. Additionally, this difference in behavior between the funds and their underlying assets suggests the existence of arbitrage opportunities. The similarity of the country funds and the US market limits the diversification they offer to US investors. In some cases an investor would have benefited more from investing in the underlying assets of the funds than from investing in these funds. In the presence of barriers to international investments, however, the funds from Brazil, Mexico, and Taiwan do provide diversification benefits. Further analyses using tests of cointegration and vector autoregression show that Mexico is integrated with the US but the markets of Brazil, India, Korea, Malaysia, Taiwan, and Thailand are not.

Another study of country funds is by Bosner-Neal et al. (1990) who employ the event-study methodology to explore the impact of market liberalization on the relation between fund prices and net asset values (NAV) in order to make inferences about market integration over the period 1981 to 1989. The results vary according to the fund examined. For instance, the Mexico and Korea Funds had significant changes in their price to NAV ratios during the three-week event window indicating that these markets were segmented from the international capital markets. Taiwan, on the other hand, seems integrated. The authors argue this may be misleading since it is known that Taiwan is a restricted market. This anomalous result could have arisen from the existence of restrictions that are not binding, or the events of interest were not important or were fully anticipated prior to the announcement/implementation of the liberalization.

Bekaert (1995) takes a comprehensive look at the integration and diversification benefits of 19 emerging markets over the period 1976 to 1992. He concludes that his predictability test does "...not yield much useful information on market segmentation." The second test shows significant correlation between the expected returns on the US and the expected returns on Malaysia and The Philippines, while the correlation between the US and Chile, Mexico, and Thailand is of the same order as the correlation between the US and Japan. This leaves 14 markets with low or negative correlation characterizing segmentation. Results from the variance-ratio test of integration are mixed and points to the lack of uniformity in the results between the different methods of measuring integration. However, two important results from the perspective of this thesis are that Latin America (Argentina, Brazil, Chile, and Mexico) seems to be internationally integration and that these markets provided diversification to US investors in the period 1986 to 1992.

Static models of integration might not reflect the more dynamic processes taking place in the emerging markets. The floating of country funds, the listing of ADRs, the issuing of international debt, and the increasing economic ties with the developed economies along with general improvements in market efficiency are expected to induce time-varying integration of the emerging markets into the world capital market. To capture this possibility Bekaert and Harvey (1994) use a conditional regime-switching model which allows for markets moving from segmentation to integration over a period of time[10]. This model is applied to the indices of 12 emerging markets over the period 1975 to 1992. From their Table 4, the hypothesis that the level of integration is fixed over time is rejected for Chile, Greece, Jordan, Korea, Thailand, and Zimbabwe.

[10] Markets can, therefore, move from a state of integration to one of segmentation. For instance, from their results it does seem that Mexico experiences this retrogression corresponding to periods of political instability.

A time-varying measure of integration (expressed as a fraction of one) for these same markets suggests that they are reasonably well integrated into the world markets, where Zimbabwe is the most segmented with a measure of 0.47 while Korea has 0.97. However, markets like India, Malaysia, and Taiwan score highly on this measure but fail to reject the hypothesis of constant transition probabilities. In the latest period (post-1990) most of the markets which reject the hypothesis of constant transition probabilities remain, as expected, integrated at similar or higher levels. The surprises in the results are that Chile experienced substantial segmentation in the latest period, as did India. Mexico showed no sign of integration using any of the measures for any of the periods; rather, it seemed to experience some degree of segmentation in the latest period.

Using monthly returns on the emerging markets, Korajczyk (1995) employs the International Arbitrage Pricing Theory (IAPT) to assess deviations from the law of one price as a means of measuring segmentation. Average mispricing of 20 emerging markets against a benchmark (the US) over a period of several years up to 1992 painted a mixed picture of market integration. Emerging markets show evidence of market segmentation when compared with the developed markets, but there is time variation and the tendency to decline towards the end of the period under study; a clear sign of increasing integration. Some markets with small mispricing measures are India (except for the mid 1980's and mid 1991), Jordan (save for relatively small mispricing in 1991 and 1992), Korea (lowest mispricing except for mid 1980's), Mexico (for the post-1989 period), Pakistan (but for the year 1991), Philippines (after 1989), and Portugal (after 1989). The general patterns here are that markets tend to become more integrated after the late 1980's following the reforms that allow more participation by foreign investors, that severe mispricing tends to follow economic reforms, and more specifically, capital market reforms, and that market integration is a time-varying process, and perhaps better results are obtained when the model reflects that. Korajczyk draws attention to the similarity in his finding on India with that of Bekaert and Harvey (1994), but notes that in his test, Mexico seems more integrated in the later years. Similarly, for Chile there was no tendency to segmentation in the post-1990 period.

Using the pricing errors from the ICAPM and the IAPT as measures of integration, Levine and Zervos (1996) compare 16 emerging markets against the average measure for the USA, UK, and Japan over a period of several years which included an event of major policy shift for each market. Argentina, which first liberalized its market in 1980, fared the worst by one measure and ended up close to the bottom when ranked by the other. The most integrated market is Jordan, by both measures. This surprising result is in contrast to Bekaert (1995) but is consistent with Korajczyk. Though Bekaert and Harvey (1994) show that Jordan's level of integration has changed over time they note that it cannot be well integrated given that there is a maximum foreign ownership restriction of 49% in most sectors, and 85% of equities are owned by citizens. Korea is shown to be reasonably well integrated but less so than India and Pakistan. Mexico is segmented according to these measures.

Errunza, Losq, and Padmanabahn (1992) note that most tests use full integration or complete segmentation as their point of reference and sometimes interpret the rejection of integration as evidence of segmentation. However, as a result of the joint-hypothesis problem, some tests of integration (using measures within the CAPM framework, say,) could be rejected, for instance, when markets are indeed integrated but the APT pricing mechanism is more appropriate to describe the return-generating process of the markets. Furthermore, the assumption of either full integration or complete segmentation may be misleading as the level of integration between markets may not fit any of the polar cases. They propose a more practical categorization of integration, the mild segmentation (or partial integration) classification, which is drawn from the earlier work of Errunza and Losq (1985a). Using monthly stock prices over the period 1976 to 1987, the hypothesis of full integration is rejected for all eight emerging markets while the mild segmentation/partial integration hypothesis is rejected only for India. Tests of complete segmentation support the evidence found elsewhere that Argentina and, more so, Zimbabwe are isolated from the influences of the world capital markets, while Brazil, Chile, Greece, Korea, and Mexico are characterized as mildly segmented. Curiously, India is not classified under this scheme as the hypotheses of full integration, mild segmentation, and complete segmentation are all rejected. Errunza and Losq (1985a) find tentative support for the mild segmentation hypothesis using nine emerging markets (eight above plus Thailand) over the latter half of the 1980's.

Table 3.1 Results of Tests of Market Integration

Author	Type of Test	Results
Developed Markets		
Stehle (1977)	CAPM	Inconclusive
Jorion and Schwartz (1986)	CAPM	Reject integration
Cho, Eun, and Senbet (1986)	APT	Reject integration
Wheatley (1988)	CCAPM	Cannot reject integration
Gultekin, Gultekin, and Penati (1989)	APT	Reject; cannot reject integration
Korajczyk and Viallet (1989)	CAPM/APT	Reject; cannot reject integration
Cumby (1990)	CCAPM	Reject; cannot reject integration
Campbell and Hamao (1992)	Latent Variable	Partially integrated markets
Mittoo (1992)	CAPM/APT	Reject; cannot reject integration
Arshanapalli and Doukas (1993)	Cointegration	Segmented; integrated markets
Foerster and Karolyi (1993)	Event Study	Evidence of segmentation
Chen and Knez (1995)	Distance Between Pricing Kernels	Reject; Cannot reject integration
Ammer and Mei (1996)	Correl'n of returns from present value model	Strong degree of integration
Sundaram and Logue (1996)	Event Study	Evidence of segmentation
Alford and Folks (1996)	CAPM	Increasing integration of markets
Naranjo and Protopapadakis (1996)	Multi-factor model	Reject integration
Emerging Markets		
Errunza and Losq (1985a)	CAPM	Cannot reject mild segmentation
Bosner-Neal et al. (1990)	Event Study	Evidence of segmentation
Errunza, Losq, and Padmanabhan (1992)	CAPM	Cannot reject mild segmentation
Bekaert and Harvey (1994)	CAPM	Cannot reject time varying integration
Bekaert and Harvey (1994)	CAPM (time varying)	Differing degrees of integration
Bekaert (1995)	Predictability; Correlation; VR	Differing degrees of integration
Bekaert and Urias (1995)	Mean-variance spanning	Differing degrees of integration
Chang, Eun, and Kolodny (1995)	Cointegration	Evidence of segmentation
Korajczyk (1995)	APT	Time-decreasing segmentation

NB: "Reject; cannot reject" applies to an early sub-period and a later sub-period, respectively. VR is variance ratio. There are several tests of integration mentioned in the thesis but are not included here as they are indirect tests based primarily on the event-study methodology.

Source: Author's compilation.

IV. Breaking Down the Barriers: Factors Aiding Capital Market Integration

The integration of the emerging markets with the world capital market is driven by "...fundamental structural changes that have increased investor demand for developing country equity shares." These fundamental changes include:

1. reduction of budget deficits,
2. stabilization of exchange rates,
3. control of inflation,
4. privatization of large state-owned entities,
5. increased private sector scope and involvement,
6. sovereign debt reduction coupled with the use of private debt and equity,
7. creation of economic zones.

These have been augmented by a process of:

- foreign investor-friendly changes to laws affecting transacting in shares,
- market-opening, e.g., removal of capital (inflows / outflows) and exchange controls,
- lifting of limitations on the proportion of foreign ownership in listed firms.

Mullin (1993) details the changes in and performance of the emerging markets that have attracted international equity investors.

More generally, the factors that cause integration of markets are (Foerster and Karolyi (1993))

- geographic proximity between markets,
- existence of trade partnerships (blocs) and currency relations,
- similarities of culture,
- general economic ties, e.g., harmonized disclosure requirements in financial markets.

Harvey (1994a) suggests that the absence of investment taxes, timeliness in the dissemination of trading information, availability and accuracy of accounting data, cross-listing of securities (and the registering of country funds), protective legal structures (such as compensation funds), and stable political (and economic) climates further motivate international investments and strengthen capital market integration.

V. How High the Barriers: The Effects of Barriers to International Investment

Black (1974) represents one of the first attempts to look at the effect of international investment barriers on capital market equilibrium[11]. To represent the barrier, he specifies taxes as a proportion of the total assets held in a national market other than the investor's. The model allows for the imposition of the barrier by either the home country of the investor (outward restriction) or by the host country of the investment (inward restriction). However, it is generally accepted that most barriers are erected by host countries, as for instance, the imposts by the Chilean government on investment by overseas investors. He further asserts that the tax is representative of "...various kinds of barriers to international investment..." These include the

[11] Solnik (1974b) develops an equilibrium model of international asset pricing, but focuses on the effect of exchange risk rather than investigating the effects of barriers to international investments.

possibility of the expropriation of foreign property, capital controls on movement in or out, reserve requirements on assets held by foreign portfolio investors, limits on the ownership of business by foreigners, and even barriers arising strictly from the lack of knowledge about the business climate in foreign countries.

Gultekin et al. (1989), with support from Bosner-Neal et al. (1990), argue that although government restrictions might be the main cause of international capital market segmentation, it is difficult to separate the effects of "...objective restrictions to trade in financial assets..." from those caused by investor "attitudes and irrationality." It is conceivable, therefore, that the removal of the objective, government-imposed restrictions on trade in financial assets might not result in the complete integration of the newly-liberalized market with the world capital markets. However, most researchers seem more concerned with the objective barriers, as are Bekaert and Harvey (1994), e.g., where the barriers of concern are all government imposed. Since taxes on investments are also government imposed, it may be advisable to treat the tax as representing only those restrictions. That is, we might not wish to think that "...the general effect of all of these kinds of barriers will be the same as the effect of the tax on international investment (Black, p.338)." Indeed, Eun and Janakiramanan (1986) state that the "...perplexing variety of barriers to international investment..." is impossible to capture in any one model.

Notwithstanding the above, Black's model indicates that market-segmenting restrictions, as represented by taxes, cause pricing anomalies of risky securities in that expected returns may diverge from returns predicted by the CAPM. Specifically, securities with large betas (measured with respect to either the world or a national market) have expected returns that are lower than that predicted by the CAPM while those with small betas have higher expected returns than predicted by the CAPM (his equation (18)). These theoretical results are in sympathy with empirical findings and may be due to restricted borrowing in the money markets (e.g., Black (1972)), use of a market proxy that is incomplete (inefficient) (e.g., Roll (1977)), and barriers to international investments. Furthermore, investors, in reaction to the tax, do not hold the optimal portfolio as expected under the CAPM. The international market portfolio and the international minimum-variance zero beta portfolio of risky assets are made sub-optimal by a preponderance of domestic securities. This overwhelming preference for domestic securities reflects the "home bias" observed by Cooper and Kaplanis (1994a,b). (See Stulz (1994) for other references).

The selection of non-optimal portfolios by investors is but one of the effects of the imposition of binding barriers to international investments. Generally, any segmentation between markets, even in the case of markets existing within the same national domain, affects the foundation upon which many corporate financial decisions are made. First, if markets were perfectly integrated, then there would be no incentive for firms to undertake certain corporate and financial decisions which serve to mitigate the effects of segmentation. It is argued that many mergers and acquisitions and even international cross-listing would be redundant. Firms would be providing no useful services for their shareholders by engaging in these actions if the owners could pursue them on their own behalf (Ragazzi (1973), Adler and Dumas (1983), Goldberg and Heflin (1995)). This is so unless the firm benefits from monopolistic control overseas, in which case it is difficult to disentangle the respective benefits.

Second, perfect integration of domestic markets is assumed under the Black-Scholes option pricing model, in that there needs to exist integration between the stock, bond, and option markets in order to remove the possibilities for arbitrage, consistent with the strong-form integration of Chen and Knez (1995). Third, Stulz (1981b) argues that only in fully integrated markets is it always optimal to diversify internationally from the perspective of the mean-variance efficiency hypothesis. If markets are not fully integrated, then the basis for comparing the reward-to-risk tradeoff across markets is tenuous to say the least. Similarly, we can expect projects (assets) with perfectly correlated cash flows to be similarly priced irrespective of the markets in which they are located, only if markets are perfectly integrated.

Fourth, internationally segmented markets affect the firm's cost of capital by making it country specific. Since under segmentation investors do not hold the optimal portfolio but rather a portfolio that is dominated by securities of their own country, the country in which capital is raised does matter to the firm. In the situation where the firm involved in raising capital is domiciled in a restricted and underdeveloped capital market, cheaper funding for projects may often be sourced overseas in larger markets with different tax structures and larger money markets (Howe and Kelm (1987)). Stapleton and Subrahmanyam (1977, p.307), in assessing the effects of "...restrictions on certain individuals investing in certain securities...", note that segmented markets lower asset prices (increase the cost of capital) and motivate the firm to seek to overcome the effects of segmentation. This it does by engaging in foreign direct investments, foreign portfolio investments, and mergers with foreign firms. Furthermore, cross-listing of a firm's shares overseas increases the stocks' liquidity, which then reduces its risk.

Jorion and Schwartz (1986) note that segmentation nullifies some of the Modigliani/Miller (MM) irrelevance propositions of corporate financial policy. In the presence of segmented markets firms may adopt hedging strategies which otherwise would be the prerogative of the shareholders. For instance, firms may engage in currency hedging to limit their exposure, make decisions between debt and equity financing, and between domestic and foreign sources. Their capital budgeting decisions are also affected by the distinction between national and international pricing. Otherwise, the capital budgeting decision in an integrated world with random exchange rates, identical investors, no tax (or at most identical tax), and no inflation, is independent of transaction currency, nationality of the investing firm, and the firm's financing decision (Adler and Dumas (1983)). With differential taxes, however, a value-maximizing overseas borrowing is possible and the investment and financing decisions are interlinked. Under full integration the MM propositions hold, and hedging decisions are irrelevant.

VI. How Many Barriers: Types Of International Barriers

The mere existence of legal barriers does not in itself prove that there is segmentation between markets. If investors have means of surmounting the barriers or if the barriers are not binding, then they do not cause distortions to the optimal portfolios of investors. The advent of country funds and ADRs broke what may have been stringent barriers to some emerging markets. However, the listing of these instruments may not be enough to obliterate the full effects of restrictions, as will become clear below.

Jorion and Schwartz (1986) distinguish barriers on the basis of whether or not they are 'Indirect' or 'Legal'. Indirect barriers include:

- substandard information on and analysis of overseas stocks,
- disclosure requirements of overseas exchanges that differ to the extent that company accounts are inadequate for informed decisions,
- cultural impediments such as mistrust of foreigners,
- any other costs of investing overseas.

Legal barriers include:

- difference in legal status of local and foreign investments,
- differential tax regimes, limitations on citizens owning foreign securities and on the foreign ownership of local securities,
- any other restrictions imposed by the country of origin of the securities.

Bekaert (1995) applies a similar classification but adds a third dimension to deal specifically with the barriers of the emerging markets which he calls Emerging Market Specific Risks (EMSRs). They include:

- liquidity risk,
- economic policy risk partly arising from macro instability ,

- political risk (often proxied by country credit rating),
- currency (exchange rate) risk.

Hietala (1989) lists legal and informational barriers and also those resulting from investors' aversion to "illiquid markets". Gultekin et al. (1989) and Bosner-Neal et al. (1990) use the broader categories of government-imposed impediments to capital movements and those resulting from investors' attitudes or irrational behavior. Black (1974) uses taxes on foreign securities holdings to represent barriers such as the possibility of expropriation, direct control on import or export of capital, reserve requirements on bank deposits and other assets of overseas investors, limits on the fraction of foreign ownership of local business, and even barriers due to unfamiliarity on the part of foreign investors.

It is frequently the case that cross-listing forces compliance with the standards of accounting and disclosure on the foreign (host) market. This removes some of the indirect or information barriers and also improves the liquidity of the security. Cognizance of this led Jorion and Schwartz (1986) to comment that if indirect (information or liquidity) barriers were the sole cause of segmentation, then cross-listed stocks (from a segmented to an internationally integrated market) would be integrated but domestic stocks would remain segmented. If both sets of stocks were to remain segmented, then this would be evidence of the more restrictive legal (government-imposed) barriers. It is clear, therefore, that listing a stock overseas need not remove the effects of all the barriers to international investments. Harvey (1995), e.g., cites Chile as one of the least investable of the markets covered by the IFC

Emerging Markets Database. Yet it has a large number of ADRs and country funds listed on the main exchanges of the US.

The different classifications of investment barriers adopted by individual authors are complementary but none is exhaustive. The indirect/legal classification comes closest to achieving this as it accounts for the existence of investor attitudes such as fear of dealing with foreigners, which partially explains the observed home bias. Similarly, it does help to explain why even between markets with similar disclosure regimes and trading practices the greater proportion of overseas investment is undertaken by institutions and not by individuals.

Hietala (1989) mirrors the above categorization but adds the dimension of fear of illiquid markets. This category is important given the unsettled argument about whether or not informed traders with private information transact in the dominant market. For instance, the emerging market in the case of an interlisting on the NYSE tends to be the less liquid, and the thinner trading may not be capable of concealing the transactions of informed traders. This categorization fits into that of Gultekin et al. (1989) although theirs is flawed in the sense that it omits barriers which are neither directly imposed by government (legal) nor reflective of investor attitudes. On the matter of reporting, for instance, governments in, say, emerging markets set minimum standards but impose no restriction on professionals in the field, who have liberty to go beyond this threshold. Their failing to do so creates barriers for potential overseas investors, separate and apart from government restrictions or investor attitudes. Interestingly though, Levine and Zervos (1996) find no robust empirical relationship between measures of stock market development (such as size, liquidity, volatility, and integration) and government attempts to legislate improvements in accounting and reporting by local firms or the introduction of investor protection laws.

VII. Jumping the Barriers: The Effects of Cross-Listing

This section briefly reviews the literature on the effects of a firm which, while listed on its national stock market, also lists on a foreign market. This is variously called dual listing, cross-listing, or interlisting. Karolyi (1996) provides an encyclopedic survey of the issues which include the price behavior within a time window around listing (and also around the announcement and application for listing), the impact of cross-listing on liquidity, and subsequent changes in the risk and cost of capital of the firm. Cross- listing is considered a part of the firm's financial policy enacted to mitigate the deleterious effects of internationally segmented markets.

Recent work indicates that the benefits of cross listing vary across firms depending on the type of ownership restrictions that exist in the home market (e.g., Domowitz, Glen, and Madhaven (1997) for series A and B shares in Mexico). This is the primary purpose of cross listing, though it is generally recognized that there are other goals which such action achieves. It is reasonable, therefore, to suggest that if markets are perfectly integrated, then the process of dual listing loses its major appeal and should have no significant impact on stock prices (returns). That is, prices in both markets should be the same when translated into a common currency as unrestricted cross-border arbitrage ensures equality of prices (returns) and risk for the one asset trading in two markets (e.g., Sundaram and Logue (1996), Alexander et al. (1988)). This is despite any tendency towards an increase in the price of the stock as a result of the new demand in the host market. Additionally, equality of prices are driven by the fact that under fully integrated and efficient markets investors in the host market are unwilling to pay a premium for the cross-listed stock. In integrated markets investors are as endowed as the firm to engage in international transactions directly and without hindrance. Hence, they will not compensate the firm for acting on their behalf.

If, on the other hand, the home market is segmented from the host market, then one expects to see an impact on returns (prices) from cross listing; this is the raison d'être of listing overseas. Several studies have been done in the developed markets[12] using primarily the event-study methodology concerning events ranging from applications for and announcements of cross-listings, where this information is available, to initial listings and trading overseas[13].

VII. A. Price Effects

Cross-listing is expected to increase the demand for and, hence, the price of the interlisted stock as investors in both markets take positions in the available shares.

[12] A partial list includes Sundaram and Logue (1996) and references therein, Lau, Diltz, and Apilado (1994), Foerster and Karolyi (1993), Howe, Madura, and Tucker (1993), Jayaraman, Shastri, and Tandon (1993), Lee (1991), Howe and Madura (1990), Alexander et al. (1988), Howe and Kelm (1987).

[13] For a recent look at an emerging market, Mexico, see Domowitz et al. (1997). Taking advantage of the different types of equity issues with various ownership restrictions, they find that there is increased volatility after listing but that this is related to changes in the flow of public information, not to liquidity or trade volume; that there is order flow migration to the US market thus reducing liquidity in the domestic market; that the increased competition between the markets lead to a reduction in the bid-ask spread in the local market; and that these effects are found primarily in the series which allowed unrestricted foreign ownership prior to dual listing.

Although this is not dissimilar to the expectations under integration, when the home market is segmented there is a stronger tendency for an increase in price (Stapleton and Subrahmanyam (1977)) [14]. Trading in the cross-listed stocks by investors in the overseas (host) market is facilitated because all transactions are in their own currency, thus avoiding the inconvenience of foreign currency translations and saving on transaction costs. Information and monitoring costs are also lower because the cross-listed firm is required to provide the host exchange with accounting and other relevant information. There is, therefore, the tendency for these combined effects to increase the demand while supply is fixed. The result is an increase in price which translates to a reduction in the cost of capital.

Since dual listing exposes the firm to more stringent reporting requirements and to the scrutiny of a larger number of analysts, the act of cross-listing may be considered a signal[15] to investors by management of its increased confidence in the prospects of the firm. The effect of the signal from dual listing is manifested in changes in the equilibrium pricing relation of the asset, a feature that has been captured by event studies. Generally, the literature suggests that the prices of the stocks increase in the first month of listing but then subsequently fall within the next year or so. Karolyi (1996) suggests that the most plausible explanations for this behavior, from a list of several possibilities, are that managers optimally time their overseas listing to coincide with a period of good performance which is not sustained and that the firms

[14] Errunza and Losq (1985a) note that restriction on foreign ownership of securities gives rise to a "super" risk premium on the stocks' return. On dual listing this is expected to be eliminated with rising stock price and lower post-listing expected return.

[15] If cross-listing provides management with the opportunity to signal to its shareholders the prospect of improved earnings, then a subsequent chance to send further signals should be the announcement of an ADR solo-split (stock split of the ADR only). Muscarella and Vetsuypens (1996) find that the solo-splits in the US are consistent with liquidity effects and not signaling.

which typically meet listing requirements are the mature ones with declining growth potential. Serra (1997), in the first comprehensive investigation of the behavior of dual-listed firms from the emerging markets, supports this finding.

VII. B. Impact on Risk

The cross-listing of a firm domiciled in a segmented market affects the non-diversifiable risk of the firm's stock by exposing it to the foreign market. That is, the volatility of returns will be different between the pre- and post-listing periods due to a change in the return-generating process. Solnik (1974a, p.365) states that "The most realistic description of the international relation of stock prices seems to be a multi-index specification taking into account both national and international factors." In other words, the post-listing returns of the stock is generated by both a local and an overseas factor as against a local factor prior to listing (see the "externality effect" below for further discussion). In turn, the firm's cost of capital is affected.

Furthermore, if interlisting reduces the impact of barriers to international investment, then the cost of capital is expected to fall by an amount which represents the premium built into the cost of capital as compensation for these restrictions. Barriers deny local investors the benefits of international diversification for which they rightly demand a premium; and some nationally priced risks can be diversified away in the international market place. This is consistent with the results that on interlisting the national beta of the stocks is reduced while there is a less than equal increase in the international beta.

VII. C. Liquidity Effects

Two recent papers focusing on the changes in liquidity due to interlisting are Jayaraman et al. (1993) and Howe et al. (1993). The theoretical foundation of the investigated hypotheses is based on the relation between information flows to the market, trading volume, and the variance of securities' returns. Hence, for certain post-listing manifestations it is difficult to separate the effects of changes in risk from changes in liquidity and to attribute causation. French and Roll (1986) document that return variance is higher during the stock exchange opening hours when there is active trading and lower when the exchange is closed (lower variance of close-open returns). They propose that trading is driven by public and private information and "noise".

Allied to this hypothesis is one which categorizes traders by the type of information they possess. A single risk-neutral informed trader with private information has the objective of maximizing profit. So as to derive maximum benefit, she trades strategically, 'releasing' her information into stock prices at a constant rate per unit of time. All private information is impounded by the security's prices by the end of the (single) trading period. Random liquidity traders have no private information and trade at random intervals while discretionary liquidity traders have no private information but have 'discretion' over the timing of their trades. A risk-neutral specialist, who comprises the other category of traders, has no private information but reacts to private information implied by the order flow of the other traders. This order flow is 'noisy' as a result of the transactions of the liquidity traders (see Kyle (1985); and Easley and O'Hara (1995) for a summary of related theories).

All categories of traders are assumed to have equal access to public information. A transaction by the informed trader releases all or part of her information into the public domain. To maximize the benefit from private information the informed trader must keep the information private until all transactions motivated by this information are completed. Informed and discretionary liquidity traders prefer, therefore, to trade in active, high-volume markets - a choice which is expected to increase variance in active markets. Furthermore, by assuming that the informed trader can maintain the privacy of her information for more than one period (assuming sequential trading hours), she will be motivated to trade in both the domestic and overseas markets to take advantage of a thicker/deeper combined market. The outcome is increased variance of the stock price due to its exposure to more private information revealed over the two markets. Cross-listing, according to this argument, will result in higher price variance[16].

Within this context, Foerster and Karolyi (1993) state the following liquidity hypothesis. In the event of dual listing there is a "winner-take-most" phenomenon whereby the more active (dominant) market becomes the preferred habitat of

[16] Others have argued in opposition to this. Liquidity traders will tend to trade in markets with the lower transaction costs. This is likely to be the domestic market in the case of, say, US cross-listed stocks (see Barclay, Litzenberger, and Warner ((1990, fn. 5) and Werner and Kleidon (1996), with caveats). Given that informed traders prefer active markets where they can hide their trades behind those of liquidity traders and since the domestic market is likely to be a dominant one, they will focus on the latter rather than shifting their transactions towards the thinner market where their information may be exposed. Private information, therefore, will not change the variance of stock prices on cross-listing. Barclay et al. (1990), in support of this, find that there was no increase in the variance of US stocks listed in Japan nor was there any increase in the variance of the Japanese stocks listed in the US.

informed traders. This leads to a reduction in the volume of trading on the domestic market but an increase in overall volume if there is disparity in the cost of trading between the two exchanges. This arises from the fact that the more liquid market attracts both the liquidity traders who seek to save on transaction costs by trading more in the less costly market and the informed traders who, in a bid to hide their information, follow the liquidity traders into the thicker markets. This idea of increased liquidity due to cross listing is also supported by Alexander et al. (1988) who argue that an added outcome of the increased demand and expanded market is smaller bid-ask spreads. In support of this, Domowitz et al. (1996) find that 75% of all trades in Mexican cross-listed stocks take place in the US.

Alternatively, the noise hypothesis asserts that trading is not based on information but rather on traders' overreaction to the transactions of others. It does have an impact on price variability irrespective of trade volume and may be of negligible duration or may persist as a 'fad', generating negative autocorrelation in the process. With extended trading hours (assuming nonsynchronous trading between the home and host markets) and a newly listed security to contemplate, it is hypothesized that the rate of reaction of traders to each other (noise) will increase causing higher variability in the post-listing price behavior. Additionally, the negative autocorrelation should be exaggerated in this period.

The role of public information in the event of a cross-listing has also been considered. That is, that the observed increase in post-listing volatility may be related to the release of public information has been investigated and rejected by some authors. If the home and host market trade sequentially, then the additional trading hours leave the dually-listed stock exposed to more public information which could lead to an increase in variance. Furthermore, the depositary receipt may react to information in the overseas market and transmit that back to the underlying stocks, leading also to greater post-listing volatility. The hypothesis that return variance is affected by cross-listing due to the arrival of public information seems not to be well supported, however.

VII. D. 'Externality' Effects

When a country previously segmented from the international capital markets starts a depository receipt program, other important issues, not previously addressed, arise. There is the question of equality between the prices of the underlying asset and the depositary receipt and the possibility of profitably exploiting any differences. Alexander et al. (1987) show that cross-listing from a segmented market into one which is integrated with the international capital market precipitates the integration of the pure domestic securities. This "externality effect" of the interlisted securities on the purely domestic securities increases with the correlation between the pure domestic and the interlisted assets. Perfect (positive or negative) correlation causes the pure domestic asset to be priced as if it too is cross listed and, hence, is a perfect substitute for the dually-listed security.

At least two implications follow immediately. The first is that, by extension of this argument, if markets are perfectly integrated, then the underlying stock and its ADR are perfect substitutes. However, in the absence of full integration where there exists segmenting barriers between the home and the host markets, this is not the case. For instance, significantly different tax regimes, information asymmetry, and capital and exchange controls will cause differences between the prices of these assets in the two markets. Karolyi (1996) points out that the underlying stock and its ADR need not be perfect substitutes, especially for those ADRs trading in the less liquid sections of the market. The prices could deviate from each other though it would be expected that without barriers arbitrage would force them to be within some no-arbitrage band (e.g. Errunza, Moreau, and Duan (1993)). Furthermore, the ADR is a combination of both the tradable asset and a bundle of services. The second implication is that there seems to be a critical mass of ADRs (size of the country's ADR program) which when reached precipitates the integration of the entire home market with the host market, and the ADR portfolio becomes representative of the issuing market's index. For instance, Diwan et al. (1992) argue that a relatively small country fund can provide nontrivial pricing efficiency for the constituent stocks. Chen and Knez (1995) state that if market integration is rejected with a representative subset of assets from each market, then it will definitely be rejected for the full set of assets.

Chapter 4. International Asset Pricing

I. Introduction

Domestic, closed-market equilibrium theories of portfolio choice and asset pricing (e.g. Markowitz (1952)) take into account the differences between investors' risk aversion, wealth, and access to information but do not explicitly consider the possibility of multiple goods with changing relative prices that differ across countries. Nor do they assume that investors may have different consumption baskets and different investment opportunity sets. For instance, the single-factor CAPM of Sharpe (1964), Lintner (1965), and Black (1972) (the SLB model) assumes that a security's expected return is linearly related to the return on the market portfolio of domestic assets. This is equivalent to assuming that markets are completely segmented. The SLB model cannot be extended to the pricing of international assets simply by broadening the local index to include foreign assets. The absence of a universal risk-free asset, different interest rates, and exchange rate risk are complicating factors[17]. Exchange rate risk poses the particular problem of producing different rates of return on the same asset for investors in different countries. Thus, given the existence of exchange rate risk, an investor's optimal portfolio is a function of her nationality.

[17] In empirical tests of the International CAPM (ICAPM) and International APT (IAPT), Korajczyk and Viallet (1989) impose the restrictive assumption that absolute PPP holds (i.e., existence of the law of one price across borders) so there is no demand for assets required to hedge exchange rate risks. Hence, the ICAPM and the IAPT can be tested under this assumption by merely broadening the domestic portfolio with international assets. In the case where absolute PPP holds, the exchange risk is not priced differently from the other risk factors since any change in exchange rates would lead to an adjustment in the price of traded goods thus leaving real relative prices unchanged. Their results show significant correlation between changes in exchange rates and the estimated risk factors, suggesting that absolute PPP might not hold and exchange rate risk is priced.

The "...existence of countries has implications for the saving and investment decisions of investors..." and gives rise to "...the foundation of international finance and makes international finance a field that is distinct from domestic finance." (Stulz (1994), p.35) The differentiating features between local and international investment, apart from the expanded opportunity sets of investors in the case of the latter, are the impact of exchange rate risk on the returns on investments across markets and the possibility of market segmentation affecting equilibrium asset pricing and optimal portfolio holdings. Firm financial policies are also affected by the existence of different countries. An international asset pricing model should, therefore, address one or both of these issues (Eun and Janakiramanan (1986))[18]. More precisely, in the international arena the existence of stochastic inflation rates which differ across countries and less-than-perfect correlation between the time-varying terms of trade and exchange rates give rise to differences in consumption opportunities. Barriers to international investments cause differences in investment opportunity sets (see below for a definition). It is imperative, therefore, that these issues be considered explicitly in the international setting.

The remainder of this chapter defines important terms in the international asset pricing literature, then reviews an international asset pricing model in which there is no difference in the consumption and the investment opportunity sets of investors across countries. In this case the portfolio holdings and pricing of assets are similar to those in the domestic setting. I then review models which assume that there are

[18] Bansal et al. (1993) pose a new challenge to research in international asset pricing. The task is "explaining forward contract and bond returns and not stock index returns" because "derivative" assets (forwards, options) have payoffs that are nonlinear in the usual risk factors used in linear arbitrage pricing. The assumption that expected returns are linear in the conditional covariances with the factors will be violated when asset payoffs are nonlinear functions of priced factors.

differences between the consumption sets of investors, followed by models which treat for the existence of barriers. I close the chapter by looking at some specific models pertinent to the remainder of the thesis.

The *consumption opportunity set* of an investor is the goods available for consumption, their relative prices, and the distribution of future (relative) prices.

The *investment opportunity set* is the universe of assets that is available for investment to the investor and the distribution of their returns.

The *price level* is the domestic price, specified in some fixed numeraire, of a specific bundle of consumption goods. It follows that price levels or price indices depend on the specified bundle and/or on the chosen numeraire.

The *real exchange rate* between two countries is the ratio of the cost of a common bundle of consumption goods in the two countries, when prices are specified in the same numeraire.

The theory of *Purchasing Power Parity* (PPP) states that the real exchange rate between two countries is equal to one, or should revert to one when there is a disturbance to the long-run ratio. If this ratio is equal to one, then *Absolute PPP* holds. If changes in national price levels in two countries tend to be equal over time, then *Relative PPP* exists.

Absolute PPP holds if:

$$P_i = e \times P_j^* \tag{4.1}$$

where $P_i(P_j^*)$ is the price level in local currency of country *i* (country *j*), and *e* is the exchange rate (units of *i* per unit of *j*).

The *law of one price* (LOP) holds if, in the absence of barriers, the price of a commodity is the same in all countries, when priced in a fixed numeraire. This is the foundation of the absolute PPP and is also called the Commodity Price Parity (CPP).

Sufficient conditions for the existence of absolute PPP are:

1) Homothetic utility functions, where the expenditure share or fraction of income expended on the constituents of the price index remains invariant to increases in income.
2) CPP holds for every constituent of the index.
3) Identical tastes across countries, which guarantees identical make-up of the individual indices.

In international finance, PPP is important since it impacts on the way real returns are measured across countries. If PPP is violated, then investors from different countries will compute their real return using different price deflators, hence obtaining dissimilar real returns. Consider a Briton who invests in a US stock and obtains a nominal return (in \$), $R_{\$}$. To obtain real return in pounds she first converts the nominal US return to a pound return, R_p, then deflates this with her pound price index:

$$\left[\frac{(1+R_{\$})(\varepsilon)}{(1+P_p)}\right]-1\equiv R_p^* \tag{4.2}$$

where $\varepsilon = e_1/e_0$ is the ratio of the exchange rate, (£/\$), at the end of the period to the rate at the beginning of the period of investment. P_p is the British rate of inflation and R^*_p is the real return for the Briton, the pound purchasing power of the \$ return. The US investor's real return is:

$$\left[\frac{(1+R_{\$})}{(1+P_{\$})}\right]-1\equiv R_{\$}^* \tag{4.3}$$

If $P_p = e \times P_{\$}^*$, i.e., if absolute PPP holds, then $R_{\$}^* = R_p^*$ otherwise the real returns are dissimilar.

II. International Asset Pricing Models: Equal Consumption and Investment Opportunity Sets Across Countries

Stulz (1994) develops a continuous-time model which assumes that there is no difference in consumption and investment opportunity sets between the investors of different countries. That is, he assumes that there is only one consumption good (this "good" can be a basket of commodities with constant and identical expenditure shares by each investor) common to all countries. Hence, there is no difference in consumption opportunities. He further assumes that there are no barriers to international investments, thus no difference in investment opportunities. These assumptions are further augmented with the usual perfect-market assumptions needed to obtain mean-variance efficiency[19]. In this model investors compute real returns using the same numeraire, the single consumption good, regardless of country of origin. This leads to (direct) utility functions which depend on the number of units of the consumption good. Portfolio decisions are set in the usual mean-variance framework. Unrestricted lending and borrowing at the risk-free rate allows preference-free portfolio holdings among all risk-averse investors; i.e., all investors hold the risk-free asset and the world market portfolio of risky assets in the proportion of their capitalization to the world market capitalization using the common consumption good as the measure of value.

Stulz (1985), with the discrete-time precursor to the above model, arrives at a similar conclusion about investors' portfolio holdings. By abstracting from the more complicated realities of differing consumption and investment opportunity sets across countries, it is possible to concentrate on the impact of "purchasing power risks" (random purchasing power of individual currencies) on equilibrium asset pricing and optimal portfolio holdings. He shows that since investors are interested in *real* returns

[19] Lognormal returns are assumed in order to overcome the problem of translating across currencies while applying the law of one price (LOP), given the problem that the product of two normal variables is not normal. The usual representation of asset price changes in a continuous-time framework, $dp_i / p_i = \alpha_i(X,t)dt + \sigma_i(X,t)dz_i(t)$, has been shown to hold when information flows follow a Brownian motion and there exists an arbitrage-free pricing system (see Constantinides and Malliaris (1995, p. 23) for reference). However, continuous-time (diffusion) processes which are stationary (i.e., α_i, σ_i are not a function of the state variable X)are not consistent with asset prices. That is, the above process assumes risk neutrality where α is a time-preference parameter, whereas asset prices reflect risk aversion. Using nonstationary processes (as above) where α_i and σ_i are functions of the state variable X, overcomes the problem but requires additional hedging portfolios by the investor.

(consumption), the choice of their numeraire currencies is not important to portfolio holdings (i.e., across currencies investors all hold the same portfolios), provided the maintained hypothesis of the same consumption basket and equal access to investment opportunities holds. That is, in the absence of barriers, the law of one price holds and since the same commodity is consumed by all investors, their numeraire is the same. Hence, real returns are the same for each investor.

The above model is referred to as the International CAPM (ICAPM). The prediction of the ICAPM that all investors hold the world portfolio fails to account for the observed home bias of investors; i.e., the tendency not to hold the world portfolio but rather to over-invest at home (e.g., Cooper and Kaplanis (1994a, b))[20]. Additionally, it is not the case that assets with zero covariance with the world portfolio have zero excess return, and assets with the same covariance with the world market are known to have different excess returns if they are in different countries. This indicates that

[20] Cooper and Kaplanis show that if a well-diversified international portfolio is one that is invested in the world's top ten stock markets in proportion to their market weights, then US investors need to reduce the domestic component of their investment portfolio by 63 percentage points (from 97%) in order to meet this criterion. There are several possible causes of home bias. First, investors consider domestic stocks to be an adequate hedge against inflation (of traded and non-traded goods) and exchange rate changes and an adequate offset to changes in relative prices which are not captured by changes in the price index. Second, there are additional costs to investing overseas, and these vary according to the country of origin of the investor. Third, domestic investors may face government-imposed restrictions on investing overseas. Fourth, foreign investors consider themselves at an informational disadvantage relative to domestic investors. Finally, domestic investors tend to be more optimistic about domestic stock returns than about foreign stock returns. On closer scrutiny, however, they suggest that markets may be segmented due to asymmetric information and to hedging of relative-price risk, but even these do not offer a full explanation for the home bias. Any other explanation can be disregarded. Cooper and Kaplanis (1994a) for instance, show that for inflation to be the cause of home bias it would require investors to have very low levels of risk aversion and asset returns that are negatively correlated with unanticipated changes in inflation rates. Assuming that the full costs of international investments are the observed costs, such as withholding taxes, investors would have to have very low risk aversion to hold their current domestic portfolios if the main causes of home bias were inflation and investment costs. In other words, to be so exposed to the vagaries of investing in a single 'undiversified' market would require very high levels of tolerance for risk.

there may be other priced risk factors other than the world market, as predicted by this version of the ICAPM.

Stulz (1994) notes that while the ICAPM has attained reasonable success in predicting expected excess returns, its failure to explain the observed home bias leads to its rejection as an adequate international asset pricing model. Within this context, therefore, alternative international asset pricing models have to be specified in order to assess the international pricing of risk and to gain insight into the degree of integration of the world capital market. This failure of the ICAPM to explain the preponderance of domestic assets in investors' portfolios is the primary motivation for the models to be considered next. In the first case, these models modify the assumption that all investors have the same consumption opportunity set by including the consequences of heterogeneous consumption opportunity sets. They then consider the case where the investment opportunity set differs across countries. That is, investment barriers and their effects on the portfolio composition and returns are explicitly reflected in the international asset pricing models.

III. International Asset Pricing Models: Heterogeneous Consumption Opportunity Sets

One important difference between the CAPM and the international asset pricing models to be considered next is the assumption, in the case of the latter, that there are multiple consumption goods available to all investors (An assumption of a common, single good is inconsistent with heterogeneous consumption). In this case, the *relative prices* of all goods are important in modeling the portfolio composition and asset pricing across borders. To achieve tractability, the relative prices of a common basket of consumption goods are compared. Two such baskets are the goods included in the consumer price index (the ratio of which is the *real exchange rate*) and the goods involved in international trade (the ratio of exports and imports, the *terms of trade*).

Dissimilarities in tastes and differences in the relative prices of commodities across countries because of tariffs, transportation costs, taxes, etc., give rise to consumption baskets which vary across countries. Relative prices also change in a manner which may cause a commodity to be expensive in one country, but at the same point in time, to be relatively cheap in another. There are several implications for international investments in this setting of country-specific consumption opportunity sets with multiple consumption goods, time-varying relative prices, and preferences for consumption goods which differ across countries. In particular, although all investors still care only about *real* returns, investors from one country assess the return on a given security differently from investors in another country. This arises from deviations from purchasing power parity (PPP) across national borders.

Adler and Dumas (1983) note that PPP deviations are significant, durable, and random. It is reasonable, therefore, to assume that they cause investors from different countries to view asset risk and return differently and to hold different portfolios. The usual assumption in portfolio theory of homogenous expectations of returns does not hold across countries, leading to a breakdown in the separation, aggregation, and asset pricing results underlying models such as the CAPM.

PPP deviations may result from differences in consumption tastes because any change in the relative prices of consumption goods will have diverse price impacts on the consumption basket of the investors of each country since the baskets are constituted differently. PPP deviations may also be caused by differences across countries in the relative prices of consumption goods which investors have available to them, even when they have the same preferences. On the basis of this "purchasing power risk", Stulz (1985) argues that investors of different nationalities will hold different portfolios (including assets other than the domestic risk-free asset and the tangency portfolio) in order to hedge against unexpected changes in the cost of their consumption baskets. These portfolios would be dissimilar across countries, reflecting the extent of the investors' differing exposure to this risk. Furthermore, if investors' hedge portfolio demands do not net to zero, expected returns on assets will be affected.

Solnik (1974b) creates a reference point for subsequent models of international asset pricing. He considers equilibrium conditions of the international capital markets under the assumption of perfect market integration[21] but accounts for the exchange rate risk dimension and the differences in consumption opportunity sets across countries. The model considers the investment opportunity set constant while assuming a single (but different) consumption good for each country, whose price is fixed in the local currency (zero local inflation of the consumption good). The relative prices of these goods across countries are captured by changes in the exchange rate.

[21] In integrated capital markets there are no differences in investment opportunity sets across countries; i.e., investors from every national group have equal access to the same set of national and international stocks and a default-free bond from each country which is risky in real terms. In other words, expected future wealth at each point in time for investor i is the same as for investor j if they have the same investment opportunities.

To develop his optimal portfolio, Solnik further assumes that there is zero correlation between the changes in the exchange rate and the returns on local securities and that the instantaneous expected change in the exchange rate is equal to zero[22]. The optimal portfolio under this model is obtained from either the own-country assets available to investors or from three mutual funds: (a) the world market portfolio of stocks, hedged by going short in (b) a portfolio of the nominally risk-free bonds of the foreign countries, (which is speculative in respect of exchange risk but not with respect to market risk), and (c) the risk-free asset of the investor's country. The fundamental asset pricing result is that the excess return of a stock over its national risk-free rate is a function of its world market risk. Given that the model uses foreign bonds as hedge portfolios, it cannot price foreign bonds which are risky in the exchange rate domain.

Stulz (1981a) develops an asset pricing model within the framework of integrated capital markets but where investors have heterogeneous consumption preferences. He assumes that capital gains are the only asset returns, there are no transaction costs, short sales are unlimited, and markets are always in equilibrium. Using exchange rates that are continuous ("smooth"), the model develops the dynamics of goods prices to allow for the law of one price to hold (except for nontraded goods) under the assumption that there is no barrier to goods arbitrage, while permitting the price index level in each country to differ in light of differences in taste. He shows that given flexible, smooth exchange rates in a one-good model, naïve PPP holds; i.e., a change

[22] Adler and Dumas (1983, p. 945) state that a possible justification for the first assumption (zero local inflation) is the fact that in some countries, the consumer price index does not change much in comparison with the exchange rates and returns on securities. However, they note that the latter (zero correlation between exchange rate changes and equity returns) is internally inconsistent and was subsequently corrected by Sercu (1980). Note also that Ross and Walsh (1982) arrive at the same predictions for optimal portfolio holdings as Solnik, but without the latter assumption.

in the domestic price level leads to an instantaneous change in the exchange rate to maintain absolute PPP. But in the present model, which assumes differences in taste and consumption opportunity sets across countries, there cannot be just one consumption good. Under a flexible exchange system the return on a foreign asset held by a domestic investor is different from the return on the foreign asset held by a citizen of the foreign country issuing the security, since in the former case both foreign price changes and exchange rate changes affect the return.

In this model investors choose their optimal portfolios from among either a set of mutual funds or a portfolio of the original risky assets available to them. It is assumed that there is a mutual fund for each good available in the investors' consumption basket in order to hedge against unanticipated changes in goods prices[23]. These portfolios will have the highest possible correlation with their respective commodity's price in the investors' consumption basket. The additional portfolio is a mean-variance efficient (tangency) portfolio of risky assets. These portfolios will be different across investors of different nationalities as a result of differences in consumption opportunity sets across countries. Hence, the tangency portfolio is not unique but the relative proportions of funds invested in risky assets common across countries are the same in each country. This result is somewhat similar to Merton's (1973) intertemporal CAPM based on additional assumptions of constant investment opportunity sets and lognormal asset returns (see Merton's Theorem 1). Stulz specifies expected excess real return as a function of the world real rate of consumption, world risk aversion, the covariance between the return on risky assets

[23] Here the prices (inflation rate) of consumption goods available in each country are used as the state variables against which investors hedge, but as noted in the literature, there are other state variables.

and the changes in world consumption, and the covariance between the risky asset returns and changes in the marginal (and average) proportion of consumption expenditures of each country.

Ross and Walsh (1982) (and Adler and Dumas (1983), their Section III) model price level changes in each country. Investors are interested in real returns and use an index to translate nominal to real wealth. The price index of an investor need not be the consumer price index (CPI) of his country of residence, as is the usual assumption, but can be "his own special index." In a world with multiple consumption goods, the use of the CPI requires restrictive assumptions. For instance, Cooper and Kaplanis (1994b) argue that since returns on equities are not highly correlated with unanticipated changes in the CPI, the use of equities as a hedge against inflation cannot explain the observed home bias in equity portfolios. However, it may be that relative price changes are more important as a source of risk but changes in the CPI do not reflect relative price changes. If returns on equities are positively correlated with changes in the cost of a single asset such as real estate, but not the general index, then an investor who is significantly exposed to the dynamics of the real estate market will not use the CPI as her index to estimate real returns. A similar argument may be made if the investor consumes non-traded goods which have different price changes from the CPI.

The Ross and Walsh paper is expositional in nature as it restates and demonstrates the two-fund separation theorem and illustrates the effects of changing the numeraire on the expected returns and on the covariances of returns between two markets. One of the fundamental contributions of this paper is that *there is a portfolio which is invariant to the price index investors use to value real asset returns.* First the model derives the risk premium on an asset as a linear combination of two portfolios, the first of which hedges against changes in the price level of each investor and is weighted by $(1-\gamma)$, where γ is her risk tolerance; the other, with weight equal to γ, is comprised of risky securities. In the situation where the investor possesses logarithmic utility, (has a relative risk aversion and tolerance equal to one), the hedge portfolio vanishes, and the result is an efficient portfolio in any index. In other words, the portfolio weighted by γ is independent of individual price indices; hence, the portfolio is the same for all investors. This portfolio is the point of tangency of all investors' portfolios in mean-variance space. The logarithmic investor in this setting is regarded as "nationless" as the make-up of this portfolio does not depend on the national currency used as a value measure.

This result obtains since, with the logarithmic utility function, to maximize the investor's utility of real wealth, log(nominal wealth/price index), is to maximize log(nominal wealth) as the price index is not affected by the investor's portfolio choices. The portfolio weighted by $1-\gamma$ is that which an investor with zero risk tolerance (infinite risk aversion) would hold. It provides the best hedge against inflation for the nominal return of the investor. It is, therefore, specific to the investor's price index.

Adler and Dumas (1983) (their Section IV) develop an Augmented ICAPM in the presence of PPP deviations. The roots of this model are in Solnik (1974b), while

Sercu (1980) corrected the assumption of zero covariances between exchange rate changes and equity returns. The model relates the expected returns on assets to their covariances with the world equities market and to their covariances with changes in all exchange rates. The ICAPM which uses the covariance of asset returns with world portfolio returns as the only source of risk assumes that investors in different countries use the same price index to deflate returns. This model is justified only if strict PPP holds (e.g., Grauer, Litzenberger, and Stehle (1976)), if investors have logarithmic utility functions (Adler and Dumas (1983)), or if there are zero covariances between exchange rates and stock returns (Solnik (1974b)). In the domestic CAPM, demand for assets comes from investors who (already) hold optimal portfolios of assets that are in fixed supply. To be induced to acquire additional assets these have to provide a given return relative to the original assets large enough to induce investors to hold both these assets in proportion to their supply. They price assets in the international market in the presence of PPP deviations so as to be compensated for (hedge against) exposure to changes in their price index (this is an inflation premium).

The result is a multi-factor ICAPM in which each asset's expected excess return is related to its covariance with the world market and to its covariances with the inflation rates of all countries. To test this model we invoke an assumption of Solnik (1974b) that there is zero covariance between asset returns in a numeraire currency and the inflation rate of the numeraire country. The expected excess return on an asset can then be expressed as a function of the covariance between the asset's returns and the returns on the world market plus the covariances between the asset returns and the exchange rates of all countries with the numeraire country.

The model by Grauer, Litzenberger, and Stehle (1976) considers multiple goods but assumes that PPP holds and investment opportunity sets are constant. By assuming also that investors consume the same goods (therefore, have same consumption opportunity sets), this model is consistent with the simple ICAPM.

IV. International Asset Pricing Models: Market Segmentation

Stulz (1994) points out that the ICAPM (or the Solnik (1974b) model) and the international version of the CCAPM are not successful in some countries. These models are not powerful enough to detect the small (negative) abnormal returns that might be caused by the existence of barriers in some countries. These small abnormal returns may help to explain the home bias since the expected excess returns on stocks with impediments to international investment are lower than the returns on freely traded securities. As such, the impediments reduce the demand for these restricted assets since the non-stochastic barriers do not lead to a decrease in the variance of a portfolio including the restricted assets commensurate with the reduction in its expected excess return. Investors would have to be compensated with superior diversification and/or hedging benefits from these stocks in order to be induced to hold them.

Black (1974) is the first to consider explicitly the effects of segmentation on equilibrium asset pricing and portfolio choice in an international setting. He assumes a two-country, one-period world (static CAPM) in which investors have constant investment and consumption opportunity sets and that foreign exchange risk is not relevant as relative prices are constant. Tax as a proportion of total assets held in one national market other than the investor's is specified as the barrier. The model allows for unlimited shortselling in the restricted market and a tax subsidy when the latter takes place. The effective tax, therefore, is on the net investment and it varies across countries. One unfortunate implication of this is that the tax rate can become infinite without achieving its primary objective, that of completely segmenting the market, since investors can take net short positions as the tax increases, gaining income in the process. All stocks in the restricted market can be held in the portfolios of the restricted investor, if only by taking a short position in them. This assumption, however, is inconsistent with the tendency of some (emerging) markets to impose a ban on shortselling.

Market-segmenting restrictions, as represented by this tax, cause pricing anomalies of risky securities in that expected returns diverge from returns predicted by the world CAPM (in which the market proxy is the world market). Furthermore, investors, in reaction to the tax, hold other than the optimal portfolios that would be expected under the CAPM. These portfolios are a mix of the world market portfolio, the international minimum-variance zero beta portfolio of risky assets, and a preponderance of domestic securities. All investors in a country hold the same portfolio of risky assets. A further contribution of the paper is to suggest a test for the presence of restrictions in international markets. Any divergence between the average return on the international minimum-variance zero beta portfolio of risky assets and the international mean short-term money market rate points to the existence of restrictions.

The model by Stulz (1981b) uses the same framework as Black (1974) but overcomes the major shortcoming of the tax subsidy obtained from shortselling. Stulz tackles the segmentation issue of international asset pricing while assuming that exchange rate risk is constant. Proportional taxes on the absolute value of risky foreign assets held by domestic investors are used to represent barriers to international investments. The major implications of this feature are that, a) domestic investors find it more costly to hold positions in foreign securities, either long or short, b) an increase in the taxes does not encourage large short positions and, c) some stocks in the restricted market will not be held by foreign investors. This is because the gains, in terms of diversification and hedging, from holding them do not compensate for the cost imposed by the tax. If there were to be nontrivial changes in the expected excess returns of these nontraded assets, then perhaps foreign investors would be attracted to including them in their portfolios of risky securities. The major ramification of the existence of these (restricted and) nontraded stocks is that the world market portfolio of (all) risky assets will not be a mean-variance efficient portfolio for foreign investors, thus confounding the mutual fund separation principle of indifference between a mutual fund including the world portfolio and another portfolio of risky assets. Furthermore, the possibility arises that the market proxy includes too many assets, rather than too few (as suggested in the Roll (1977) critique).

The suggestion by Solnik (1977, p. 505) that "...the efficient way to test for segmentation would seem to be to specify the type of imperfection which might create it and study its specific impact on portfolio optimality and asset pricing..." has not gone unnoticed as at least three papers have taken this approach to modeling segmentation. (This is separate from imposing an all-encompassing tax as discussed previously.) Errunza and Losq (1985a), Eun and Janakiramanan (1986), and Hietala (1989) model segmentation on the assumption that there is a maximum fraction of a firm's shares which is accessible to the aggregate investors of other countries, and this fraction is the same across firms. The models assume a two-country, one-period world where investors' utility is defined solely on the basis of the homogenous expectations of the mean and variance of end-of-period wealth. (These are within the ambit of the static CAPM). Exchange rate risks are assumed away, and the risk-free rate is the same across markets and equal for the unrestricted and restricted investor groups; (i.e., the money markets are internationally integrated). Errunza and Losq set the fraction of ownership by foreign investors at zero (a complete ban), whereas the Eun-Janakiramanan model generalizes this. Hietala applies a similar model to the specific conditions of the Finnish stock market.

In the case of a partial ban with restrictions that are binding, the equilibrium prices of the restricted stocks are affected since there will be excess demand by the aggregate nonresident investors leading to higher prices than would be available in unrestricted markets. The premium that the foreign investors from the unrestricted economy are willing to pay is a function of their aggregate risk aversion, given that the more risk averse they are the more acute will be their need to avoid the diversification loss from not holding an optimal overseas portfolio[24]. When the aggregate risk aversion is fixed, the premium depends on the severity of the constraint and on the "pure" restricted market risk[25]. On the other hand, the resident investors under ordinary circumstances would have demanded less of their own-country securities than are now in supply (given the price increase). This being the case, they will demand a discount on the available shares. The result is that two prices for the same securities are observed in the market place. The legal barrier which restricts equity ownership will have to be framed in such a way that it also impedes the arbitrage opportunities for the resident investor[26]. (See Eun and Janakiramanan (1986), Hietala (1989), Diwan et al. (1992), and Bailey and Jagtiani (1994) as to how this may be achieved).

In summary, the above models of market segmentation use the CAPM as a point of reference in applying the usual assumptions of homogenous expectations of the investors from both the restricted country and the (foreign) unrestricted country. This ignores differential asymmetric information between the investors as a source of segmentation. The models also utilize the assumption of normality of asset prices in order that expected utility can be a function of only the first two moments of the end-

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[24] In discussing the premium (fund price less net asset value) frequently observed on closed-end country funds, Bosner-Neal et al. (1990, p.523) cite it as an approximation of the "...amount the marginal (US) investor is willing to pay to avoid ... restrictions."

[25] The *pure restricted market risk* of a security is defined as the difference between the covariance of the restricted security's returns with the restricted market portfolio and the covariance of the restricted security with the return on the "adjustment" or "diversification" portfolio. The latter is a foreign (unrestricted market) portfolio which is most highly correlated with the restricted market portfolio which when perfectly correlated provides "foreign diversification benefits at home" (see Errunza and Losq (1985a)). It follows that a partial explanation of the "home bias" observed in national markets is the existence in the 'home' market of an adjustment portfolio whose returns are perfectly correlated with the returns on the overseas' market.

[26] Diwan et al. (1992) suggest that for markets issuing country funds, under certain conditions, there should be no impediment to local investors taking advantage of any existing arbitrage as it serves to equate the local price of the stock with that in the foreign market thus reducing the cost of capital of the firm and aiding stock market development.

of-period values of securities. Additionally, they treat the riskless rates across countries as the same. Presumably, the segmentation affecting the markets for equities could also impact on the money markets, nullifying this condition. It is usual also that the models impose the condition that one market is not restricted to the other; i.e., the investors in one country are allowed to invest freely in the other, but not vice-versa. Finally, the models consider only the demand side of the respective markets and assume that there are no changes in supply over the single period under consideration. It can be inferred from these models that with closer integration there is increased benefit to investors in both markets, primarily from improved chances of expanding the investment opportunity set which reduces the volatility of future consumption. This may lead one to conclude that integration is always good for both sets of investors (from the formerly restricted and the unrestricted economies). This has been questioned in the literature, however (e.g., Basak (1996) below).

V. Other Models of International Asset Pricing

V. A. Consumption Asset Pricing Models

The consumption-based capital asset pricing model (CCAPM) provides an alternative approach to testing for the effects of segmentation in international capital markets. The CCAPM treats for time-variation in the investment opportunity sets across countries. The use of the CCAPM in this regard is motivated by a possible misspecification of models (such as Adler and Dumas (1983, Section IV, eqn. 14)) which hedge against exchange risks (deviations from PPP) but treat the investment opportunity set as nonstochastic. The assumption of constant investment opportunity sets means that there is no hedging against the time-variation in the joint distribution of asset returns. However, when the investment opportunity set is allowed to change, the model requires additional hedge portfolios to specify asset prices and optimal portfolios, leading to empirical intractability. To overcome this, the expected-utility maximizing agent "...exploits the condition that the *expected* product of the payoffs of assets and marginal utility has to be the same for all assets to insure that expected utility is maximized." (Stulz (1994, p. 24)). This leads to a (continuous-time) framework in which the risk of an asset is measured as the covariance of its return with the growth in consumption. The expected excess return on a security, therefore, is equal to its consumption beta times the excess return on the portfolio whose real return is most highly correlated with consumption growth. (This portfolio is mean-variance efficient in an intertemporal setting, Constantinides and Malliaris, (1995)). In equilibrium, this holds for securities of any single country. Its failing to hold for one country while holding in another may imply that the one faces international investment barriers while the other has unimpeded access to all securities. To test for integration, therefore, is to ascertain if the model holds for world consumption. When world consumption replaces national consumption, the CCAPM becomes the International CCAPM - like the CAPM to the ICAPM - capable of being used to detect segmentation. Stulz (1985) accentuates its advantages, viz., its application is not conditioned on any specification of the exchange rate process, it is consistent with general equilibrium models[27], and it can easily be made to capture barriers to

[27] See Dumas (1994) for a brief review of international capital markets along the partial- and general-equilibrium divide. Note that the static (one-period) asset pricing models are treated as general equilibrium models because, although they do not explicitly treat the supply side of the assets under consideration, the reasonable assumption that supply is fixed is invoked (see Merton (1973, p.870-871)).

international investment. Harvey, Solnik, and Zhou (1994) point to difficulties in using international consumption data, a matter which could affect the results of tests of consumption-based asset pricing models[28].

Cumby (1990) and Wheatley (1988) recently used the International CCAPM. Wheatley employs a discrete-time version of Stulz's (1981a) consumption-based model to test international integration. Like the latter model he does not assume that the investment opportunity set is constant but rather that it changes with the state variables. Furthermore, investors from different countries have different consumption opportunity sets. Under these conditions the law of one price (LOP) need not hold and deviations from PPP arise from both differences in tastes and relative prices of goods (violation of the LOP). Though the model's primary goal is the asset pricing consequences of his assumption, the paper does mention that, as in the Stulz model, investors will hold a portfolio to hedge against changes in the price index of their consumption basket. The expected excess return on a risky asset is proportional to the covariance of the returns on the asset with the rate of growth in consumption; the factor of proportionality is the investor's relative risk aversion. Under market segmentation, captured by a tax on both long and short positions in the foreign asset, the expected excess return is augmented by the tax rate.

Cumby (1990) tests the proportionality, across all assets, of the conditional covariances between real returns of risky assets and the rate of growth of consumption. This is the original specification of the consumption-based asset pricing

[28] Aggregate consumption data are fraught with errors; also, the consumption betas reflect the impacts of state variables which, if random, will cause the betas to be nonstationary (Cho et al. (1986)).

model. His model makes use of the hypothesized constancy of the ratios of consumption betas if the CCAPM is to hold.

V. B. International Arbitrage Pricing Theory (IAPT)

The domestic APT of Ross (1976) has been shown by Solnik (1983) to hold in the case where it prices international assets for investors of different nationalities and national currencies. The IAPT is an extension of the domestic (nominal) model to account for differences in consumption tastes and relative price (exchange rate) uncertainty. Like its domestic counterpart it models asset and currency prices as a function of multiple sources of risk. Investors from different countries estimate real returns in their own currencies. This causes difficulties with aggregating across countries, and in the case of models requiring the use of portfolio returns (e.g., returns on the world market portfolio in the international CAPM), compounds the problem of finding an internationally efficient portfolio. The IAPT overcomes this as there is no need to model the differences between investors provided they believe that asset returns follow a *k*-factor return generating model. Solnik shows that the *k*-factor model holds regardless of the numeraire currency in which it is specified. This is the quintessential result of the IAPT and is derived from the assumption that exchange rates follow the same factor structure as stock prices. Intuitively, the IAPT is invariant to the denominating currency since international factors are common across nations and are not restated into the currencies of the investors, unlike the case of portfolios of the original assets used in place of factors. Consequently, even where nations experience different and stochastic rates of inflation, any arbitrage portfolio which is nominally riskless for one investor/currency will be risk-free for any other. The IAPT is not an utility-based model, but it requires the existence of perfect capital markets (integrated markets in particular) and a nominally risk-free asset[29] (which means the exchange rates follow the same *k*-factor model as the asset returns). Thus, exchange rate variability is priced to the extent it is a pervasive risk factor.

The substantive assumption of the Solnik (1983) model is that exchange rates follow the same factor structure as the asset prices allowing him to use the arbitrage arguments employed in the APT to prove his international APT. Ikeda (1991) argues that it is likely that the introduction of exchange rate risk into the problem would change the arbitrage condition. Moreover, the process of extracting international factors which adequately describe the dynamics of both the risky assets and foreign currency, while achieving negligible idiosyncratic risks, is empirically intractable. He, therefore, does not assume that exchange rates follow the same factor structure as asset prices. When a different evolution of currency prices is specified, the nature of the arbitrage portfolios change. The usual process of selecting weights to form a riskless portfolio with zero expected return does not result in a risk-free portfolio. Ikeda proposed a riskless portfolio from investments in the risky assets fully financed by going short in the respective national bonds. This is a well-known means of protection against exchange risk. The result is a *k*-factor model of expected stock return adjusted for a nominal bond return and a random exchange rate component. This linear factor model is specified in any local currency as opposed to a numeraire currency as in the Solnik (1983) model.

[29] Solnik (1983) derives similar results when there is no nominally risk-free asset. The essence of the model still holds but the factors now include the different currencies or a combination of them.

Early empirical support for the currency invariance of the IAPT is furnished by Cho, Eun, and Senbet (1986) where returns for 11 of the developed stock markets are tested for integration. The same factor structure (number of statistically estimated factors) held in dollars and in yen, even though the hypothesis of integration between the markets was rejected for the entire sample, though not for all pairs of markets. Several other papers employing the IAPT appear in the literature; these include Gultekin et al. (1989), Korajczyk and Viallet (1989), Mittoo (1992), Korajczyk (1995), and Levine and Zervos (1996). Naranjo and Protopapadakis (1996) apply a version of the APT to tests of integration between the three major US stock markets, while Bansal et al. (1993) develop a nonlinear model of the IAPT which enables them to price derivative assets whose returns are nonlinear in the factors.

V. C. Intertemporalizing the CAPM in International Capital Markets

The papers by Black (1974), Stulz (1981b), Errunza and Losq (1985a) and the others based on the static CAPM have been criticized in a recent paper by Basak (1996). The above models propose asset pricing, portfolio choices, and welfare considerations in a setting where the state of integration of the international bond markets is not explicitly considered, where the effect of segmentation in the market for risky assets has no impact on the interest rates, and under which the markets are used only to aid in the acquisition of risky securities[30]. Eun and Janakiramanan (1986), for instance, simply "...assume that the risk-free interest rate expressed in any currency, either

[30] Note that in the CAPM framework the excess return on a risky asset i, $(R_i - R_f)$, is interpreted as the latter being financed by shorting the risk-free bond (R_f).

domestic or foreign, is identical." There is no consideration in these models that the bond market is used for intertemporal borrowing and lending in order to smooth consumption over different periods even though it may be reasonable to suppose, especially in emerging economies, that this motive dominates the need for achieving diversification. Given these two separate objectives (risk sharing and consumption smoothing) of entering the bond markets, the effects of integration may be different depending on which motive dominates at the time of increasing integration. That increased integration between markets is mutually welfare improving cannot be taken as given. In fact, this argument breaks down when faced with the fact that segmentation is prevalent even when these models suggest that integration is always better for both markets involved.

Basak, therefore, makes two main contributions to the current literature. The first is to consider explicitly intertemporal consumption and endogenous interest rates, and the second is to reconsider asset prices, demands, and the distribution of the benefits of integration. Several of the usual CAPM-type assumptions are employed. Of note is the assumption that there is only one consumption good, hence the exchange rate between the two countries considered is not explicitly treated[31]. To capture the intertemporal consumption aspect of the model, each country is endowed with a fixed supply of a time-zero consumption good from which utility is derived in addition to that at time one. An intertemporal utility function (instead of the von Neuman-

[31] It is worth restating at this point that in the intertemporal setting investors/consumers are required to hedge against the possibility of a changing investment opportunity set requiring that the expected return on an asset depends on the covariances of its returns with the returns on the hedging portfolios (Merton (1973)). To avoid the complexities in a simple specification using the one-factor CAPM, it is usual to assume log utilities for the economic agents, existence of strict PPP, or zero correlation between exchange rate changes and stock returns in a deterministic or zero inflation setting.

Morgenstern additively-separable function) is used[32] to overcome the problem of separating the risk aversion effect from the (intertemporal) elasticity of substitution between consumption at different points in time. The author takes a nonpolar approach to segmentation as in Errunza and Losq (1985a) and analyses the different market structures, i.e., completely segmented, mildly segmented/partially integrated , and fully integrated.

Under this setting, several of the results of the static CAPM relating to asset prices and welfare break down:

a. The risk-free interest rate increases on integration by an amount commensurate with the benefit from integration. The improved time-one wealth (consumption) position arising from the diversification benefits of integration causes consumption smoothing forward (to time zero) giving rise to excess demand which leads to higher interest rates (i.e., the marginal rate of substitution between the periods increase) since time-zero supply is fixed. If, as mentioned above, the risky asset is financed by shorting bonds, then an increase in interest rate will affect the demand for risky assets, hence affecting the prediction of models which do not consider this increase.

[32] Ferson (1995) points out that *risk aversion* has to do with a consumer's concern about the variation in her level of consumption across different states of the world at a particular point in time, where as the *intertemporal elasticity of substitution* is about changes in consumption over time, and is not necessarily related to risk. In time-separable models, such as the von Neuman-Morgenstern model, the curvature (second differential) of the utility function acts as both the risk aversion and the elasticity of substitution parameters. The two are usually inversely related in the models assuming constant relative risk aversion (CRRA). The utility function employed by Basak allows for the separation of these two effects.

b. The price of the unrestricted asset (from the integrated market) is increased. While the covariance structure of the static CAPM is maintained, the prices of the securities are altered with respect to the latter model's prediction. The price of the formerly ineligible asset from the restricted market may or may not increase on integration. Given the increase in interest rate and the asset-switching behavior of investors which follow, the static model is likely to introduce biases in the prices as this is not considered.

c. The welfare of one country may be decreased on integration. The assumption previously is that both markets benefit positively from reduction in segmentation. Both countries will gain from the increased diversification but the country that has limited time-zero consumption or good future consumption prospects may borrow in order to smooth consumption forward. The increase in interest rates attendant with integration will make borrowing more costly thus resulting in a loss of welfare if the consumption smoothing dominates. The paper demonstrates that there may be a loss of welfare even for a net lender in the international bond markets. That is, the country with high levels of time-zero consumption which chooses to lend at time zero so as to increase its time-one expected consumption, may suffer a loss of welfare.

International asset pricing, particularly from an empirical perspective, generates substantial interest in the literature. This is in part driven by the changes taking place in the emerging economies of Asia, Latin America, Europe, the Middle East, and Africa. As these markets introduce regulations and trading practices which are (foreign) investor friendly and consistent with those in the developed markets the investment opportunity sets of the investors from the latter markets expand, driving further interest in these emerging markets. Stulz (1994) points out that most empirical work in the area uses stock indices rather than individual assets. However, given that the indices of the emerging markets are not fully investable, it is imperative that these tests be conducted with portfolios of individual assets, ADRs, and country funds. In the empirical essays of this thesis I use ADRs and country funds from several emerging markets to conduct tests of international asset pricing.

New empirical methodologies are also being employed in the studies of international asset pricing. For instance, several earlier works used the generalized method of moments (GMM, Hansen (1982)) to test the (international) asset pricing models (e.g. Harvey (1991), Dumas and Solnik (1995)). Recently, however, the GARCH models have been used in these tests because they facilitate the specification of the second moments, which allows the researcher more flexibility to investigate the dynamic behavior of quantities of interest to investors (Chan et al. (1992), De Santis and Gerard (1996a, b).

Chapter 5. Methodology

I. Introduction

In this chapter I discuss some of the salient features of the primary techniques employed in the empirical chapters of the thesis. These are the Autoregressive Conditional Heteroscedasticity (ARCH) models and Mean-Variance Spanning. In the empirical chapters, I also describe aspects of the vector autoregression (VAR) and the generalized method of moments (GMM) as applied in the thesis.

II. A. The Autoregressive Conditional Heteroscedasticity (ARCH) Model[33].

The motivation for the ARCH model stems from the observation that for daily and monthly stock prices, large (small) price changes tend to be followed by large (small) changes of random sign (e.g., Fama (1965)). This is called "volatility clustering". There is also the tendency for stock returns to exhibit leptokurtic (peaked at the mean) and platykurtic (fat tailed) distributions (implying increased likelihood of large price changes of either sign) which are usually captured by the conditional heteroscedasticity of these models. A further justification for the model's widespread use in finance is that the GARCH(1,1) approximates the diffusion process of many economic time series, a feature which underlies several continuous-time theoretical constructs (e.g., Merton (1971, 1973)). However, ARCH models make strong assumptions about the functional form of the second moments of returns and it is

[33] Much of this review draws on Mills (1993).

known that if individual assets follow an ARCH process, a portfolio of such assets need not follow this process; i.e., there is no aggregation[34]. While the ARCH models allow for the efficient modeling of conditional variances, they do not inform us about the "...sources of changes in volatility..." (King, Sentana, and Wadhwani (1994)). In the same vein, Bollerslev (1989) sees the ARCH family as only a statistical device reflecting the observed dependencies in stock returns and suggests that what is more interesting is a theoretical explanation of the time-variation in the conditional moments of returns, thus justifying the use of ARCH [35].

ARCH (q). The ARCH (q) specification by Engle (1982) is:

$$R_t = \mathbf{X}'_{t-1}\Gamma + \varepsilon_t \qquad \text{where } \varepsilon_t | \Omega_{t-1} \sim N(0, h_t) \text{ and } \varepsilon_t = \sqrt{h_t}\,\eta_t \tag{5.1}$$

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 \tag{5.2}$$

where R_t is the conditional return on the portfolio of assets, h_t is the conditional variance of the forecast errors, ε_t, $\eta_t \sim$ IN(0,1), is the underlying, independent error structure of mean zero and unit variance, i.e., standard normal, $\mathbf{X}$ is a $k\times 1$ vector of

[34] Nelson (1991), in motivating the (exponential) EGARCH points to some other specific shortcomings of the GARCH model such as the assumption that only the magnitude and not the sign of the prediction error is important (the leverage effect) and the need to impose nonnegativity constraints on the parameters.

[35] Bollerslev, Chou, and Kroner (1992) list a number of possible causes of ARCH in speculative asset returns including arrival of news in clusters, nonsynchronicity between economic and calendar time (*time deformation*), and some forms of market mechanisms (e.g., automated trade execution systems). Other authors have suggested that the following macro- and micro-economic factors give rise to ARCH: clustering in trading volumes, nominal interest rates, dividend yields, base money supply, oil price index, the business cycle, and financial crises.

exogenous variables and may include lagged dependent variables and a constant, and Γ is a $k \times 1$ vector of parameters. A positive conditional variance is guaranteed when $\alpha_0 > 0$, and $\alpha_i \geq 0$ for $1 \leq i \leq q$. The information set is those instrumental variables which predict R_t, $\Omega_{t-1} = \{R_{t-1}, \mathbf{X}_{t-1}, R_{t-2}, \mathbf{X}_{t-2}, \ldots\}$. Since $\varepsilon_{t-i} = R_{t-i} - \mathbf{X}'_{t-1-i}\Gamma$, $i=1,\ldots,q$, then h_t is a function of the information set. For stability of the system (stationarity of squared error terms) all the α_i must be less than one and should sum to less than one; i.e., $\sum_{i=1}^{q} \alpha_i < 1$.

GARCH(p, q). If the ARCH (q) model requires a large q, then the non-negativity constraints on α_i may be violated leading to a negative variance, h_t. To avoid this oddity, some authors have adopted an arbitrary declining lag structure on α_i (e.g., Engle et al. (1987)). A more parsimonious representation that also overcomes the problem allows the conditional variance to be a function of past conditional variance and squared errors. The generalized ARCH, GARCH(p, q), model (Bollerslev (1986)) results:

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i}, \tag{5.3}$$

where $p \geq 0$, $q > 0$, $\alpha_0 > 0$, $\alpha_i \geq 0$ for $1 \leq i \leq q$ and $\beta_i \geq 0$ for $1 \leq i \leq p$ to ensure a positive variance[36].

[36] In empirical work these inequality conditions are sometimes violated without misspecification of the variance. Weaker conditions can be imposed to obtain positive variance. These are imposed on the parameters of the infinite ARCH model derived from the GARCH(p,q) model (see Bera and Higgins (1993)).

GARCH(p, q) as an Infinite ARCH(∞). We can show that the GARCH is an infinite ARCH by rewriting the conditional variance as:

$$h_t - \sum_{i=1}^{p} \beta_i h_{t-i} = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 \tag{5.4}$$

$$h_t(1-\beta(L)) = \alpha(L)\varepsilon_t^2 + \alpha_0, \tag{5.5}$$

where $x(L) = x_1 L + x_2 L^2 + \ldots + x_m L^m$ is a polynomial in the lag operator L. If the system is stationary (roots of the polynomial {1- β(L)=0} lie outside the unit circle), then

$$h_t = \alpha_0(1-\beta(1))^{-1} + [(1-\beta(L))^{-1}\alpha(L)]\varepsilon_t^2, \tag{5.6}$$

where $\beta(1)$ is the sum of the parameters β_i and the first part of the equation is a constant. The part in [square brackets], when expanded, gives another polynomial of infinite order in the lag operator, thus leading to an infinite ARCH.

GARCH(p, q) as an ARMA(r, p). The GARCH process can be shown to follow an ARMA process. Define the prediction error $\nu_t = \varepsilon_t^2 - h_t$ and add this relationship to each side of equation (5.4) to substitute out h_t in the GARCH (p, q) model:

$$\varepsilon_t^2 = \alpha_0 + \sum_{i=1}^{r} (\alpha_i + \beta_i)\varepsilon_{t-i}^2 + v_t - \sum_{i=1}^{p} \beta_i v_{t-i} , \tag{5.7}$$

where r is max(p, q), α_i=0 for $i>q$ and β_i=0 for $i>p$.

Given the relation between ε_t^2 and h_t (e.g., equation (5.1)), it is clear that $E[v_t | \Omega_{t-1}] = 0$, hence, $E[E(v_t | \Omega_{t-1})] = 0 = E[v_t]$, from the law of iterated expectations. Similarly, $E[v_t\, v_{t-i}] = E[E(v_t\, v_{t-i} \mid \Omega_{t-1})] = E[v_{t-i}\, E(v_t | \Omega_{t-1})] = 0$, for $i \geq 1$. v_t, therefore, are serially uncorrelated (thus the importance of treating for autocorrelation in the estimation), heteroscedastic, martingale differences with expectation zero. This reveals then that ε_t^2 follow an ARMA (r, p) process where the AR parameters are $\alpha(L)+\beta(L)$ and the MA parameters are - $\beta(L)$. It follows immediately that ε_t is stationary iff $\alpha(1)+\beta(1) <1$. The proximity of this sum to one indicates the persistence of the conditional variance; i.e., the duration of the impact of a shock to the system[37], or the extent to which information in one period is able to predict volatility into the distant future. The significance of the coefficients α_i and β_i, respectively, indicates the presence of ARCH and GARCH effects. The relative magnitudes of these coefficients tell whether return innovations or past variances drive future volatility. For instance, if α_i is greater than β_i, then this implies that return surprises have the greater influence on future volatility. The GARCH coefficients α_i, β_i, and the lag orders of p, q can be obtained from the ARMA respecification (e.g., Bollerslev (1989)). That ARCH follows an AR

[37] Bollerslev et al. (1992) summarize the existence of volatility persistence in stock, interest rate, and exchange rate data.

process is not difficult to demonstrate, also. Bollerslev et al. (1992) note that the GARCH(1,1) is usually a suitable specification in most empirical work.

GARCH-in-Mean. The GARCH(p, q)-M model was proposed by Engle, Lilien, and Robins (1987). An early application to stock returns is by French, Schwert, and Stambaugh (1987). In the GARCH(p, q)-M formulation the conditional mean is a function of the conditional variance (the conditional standard deviation or log(variance)):

$$R_t = \gamma h_t + \mathbf{X}'_{t-1}\Gamma + \varepsilon_t \tag{5.8}$$

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i} \tag{5.9}$$

This specification captures the essence of the risk-return trade-off underlying mean-variance theory in finance[38]. Allowing time-varying variance to influence the mean[39]

[38] Backus and Gregory (1993) examine the fundamental issue of whether any conditional second moment of asset returns can account for the time-variation in expected excess returns. Take, e.g., the static CAPM, $E[r_i] = \lambda \mathrm{cov}(r_i, r_m)$, where $E[r_i]$ is expected excess return on asset i, r_m is the excess return on the market, and λ is a factor of proportionality, in this case, the market risk premium scaled by its variance. Tests based on this model usually assume that all the parameters are constant (see Ferson (1995); and Harvey (1989, 1991), Jagannathan and Wang (1996) for conditional versions). Tests of asset pricing using GARCH-M and other specifications which keep λ constant but allow for time-varying expected excess returns and conditional (variance or) covariance have assumed, and found, that the price of risk is a monotonic function of the asset's covariance with the market. Backus and Gregory question whether the empirical findings are supported by a theory of dynamic asset pricing that predicts a relation between risk premia and conditional second moments. They find that depending on the preferences of the representative agent and the vector of state probabilities (since both the risk premium and the second moment are time-varying - dependent on the state), this trade-off can be increasing, decreasing, flat, or nonmonotonic. Only with additional restrictions can the theory of dynamic asset pricing support the GARCH-M model and allow straightforward interpretation of its parameters, in particular the coefficient on the conditional covariance term, λ, usually interpreted as the relative risk aversion.

[39] This point is important as several recent studies (most notably Fama and French (1992); Jagannathan and Wang (1996) cite others) have questioned the validity of the static, one-factor CAPM which

reflects the fact that as the "...degree of uncertainty in asset returns varies over time, the compensation required by risk averse economic agents for holding these assets, must also be varying." (Engle et al. (1987)). This approach is applicable to the pricing of a single asset and is not fully consistent with determining the appropriate risk of an asset added to a multiple-asset portfolio. In the latter case, portfolio theory (Sharpe (1964), Lintner (1965), Black (1972)) treats the covariance of an asset's return with some efficient portfolio of assets as a measure of priced risk. This is the motivation for the application of a multivariate GARCH framework (Bollerslev, Engle, and Wooldridge (1988)) to tests of the CAPM using conditional (time-varying) covariance. "This essentially assumes that agents update their estimates of the means and covariances of returns each period using the newly revealed surprises in last period's asset returns. Thus agents learn about changes in the covariance matrix only from information on returns (p. 119)."

assumes a constant beta (or factor loadings in APT-type models). Fama and French (1992) have drawn many reactions. One of the important criticisms of tests of the CAPM which found "flat" results comes from Roll and Ross (1994) (and Roll (1977)) which essentially states that if the index used in these studies is not efficient then the cross-sectional relationship does not hold exactly and so other variables (size, dividend yield, book-to-market value, etc.) may have explanatory power. Conversely, any efficient portfolio can be used in place of the usual index and the CAPM will hold, hence, only beta is necessary to capture the predictions of the CAPM. Furthermore, failure to find a significant beta could arise from the existence of an alternative equilibrium asset pricing relationship, e.g., the APT of Ross (1976). Critiques include: Kandel and Stambaugh (1995), Kothari et al. (1995), Kothari and Shanken (1995), Pettengill et al. (1995), and Kim (1995). When Jagannathan and Wang (1996) use a conditional CAPM and include a proxy for returns on human capital, the firm-size effect of Fama and French is not significant. This is support for those who attribute part of the predictability of stock returns by factors other than beta and the apparent "flat" beta found by Fama and French (1992) to time-varying equilibrium expected returns driven by changing betas and risk premia (e.g., Ferson and Harvey (1991), Ferson and Korajczyk (1995)), rather than to market inefficiencies. Cutler, Poterba and Summers (1991) give an alternative "speculative dynamics" interpretation to the observed predictability of returns. See Ferson and Harvey (1993), Bekaert and Hodrick (1992) and references therein, Harvey (1991), Sentana and Wadhwani (1991), Ferson and Harvey (1991), Bollerslev et al. (1988), and Keim and Stambaugh (1986) for more on predictability of returns, while Hawawini and Keim (1995) have a review.

In some cases the source and structure of the observed serial correlation and heteroscedasticity of stock returns are known and this specification is flexible enough to impound their effects. The disturbances of the conditional return may follow an autoregressive[40], AR(p), or moving average, MA(q), or an ARMA(p, q) process. The particular type can be deduced from the autocorrelation function, ACF, or the partial ACF (PACF), e.g., and then treated. One consequence of autocorrelation is to increase the probability of obtaining an integrated ARCH when the true model is stationary (Bera and Higgins (1993)). If, for instance, the data has correlated disturbances as well as ARCH errors, then we can correct the MA(1) error by estimating the conditional return as:

$$R_t = \gamma h_t + \mathbf{X}'_{t-1}\Gamma + \theta\varepsilon_{t-1} + \varepsilon_t \tag{5.10}$$

The AR(1)-GARCH-M is represented by:

$$R_t = \gamma h_t + \mathbf{X}'_{t-1}\Gamma + \phi R_{t-1} + \varepsilon_t \tag{5.11}$$

[40] I suspect that the cause of most of the autocorrelation in the emerging markets is nontrading (and nonsynchronous trading), with the speed of information processing by market participants, day-of-the-week effect (see Akgiray (1989)), bid-ask bounce, price rounding, and the imposition of a ceiling on price changes (see Kim and Rogers (1995)) as secondary factors. The positive (negative) autocorrelation in the returns on stock indices (individual stocks) is a well-documented fact dating back at least to Fama (1965) and Fisher (1966). The papers by Cohen, Hawawini, Maier, Schwartz, and Whitcomb (CHMSW) (1980, 1983a, b) and CMSW (1978, 1979, 1986) deal comprehensively with the observed phenomenon, its causes and consequences. Others such as Scholes and Williams (1977) and Dimson (1979) have developed methods of overcoming the effects of autocorrelation on measuring systematic risk (beta), while several authors like Jokivuolle (1995), Stoll and Whaley (1990a), Blume et al. (1989), and Harris (1989) attempt to correct for autocorrelation in the index by estimating the 'true' unobserved index. Lo and MacKinlay (1990) note that a significant portion of autocorrelation in the (NYSE) index may not be the result of nonsynchronicity. Cutler, Poterba, and Summers (1991) assert that nontrading could not be the cause of autocorrelation they find in markets for foreign exchange, gold, and bonds. But the fact that futures markets tend to be less autocorrelated than spot markets lends support to the nontrading proposition. Roll (1981) notes that the autocorrelation is spurious, merely a consequence of the way records of prices are kept and updated.

where the lagged dependent variable R_{t-1} is explicitly stated. The heteroscedasticity in the errors is then treated by the GARCH approach in the conditional variance. If **X** contains the lagged dependent variable, then (5.10) is an ARMA-GARCH-M.

II. B. Multivariate GARCH Models

The multivariate GARCH makes use of the fact that the assets in the multi-equation system may be reacting to the same market information and, hence, may have covariances conditional on the common information set. In other words, the multivariate system captures the important co-movements or cross-market transmissions between the assets arising from the same information. Furthermore, in modeling the interaction between the markets, as in tests of intermarket spillovers, e.g., this framework obviates the generated-regressor problem caused by first having to estimate the "volatility surprise" in one market before using it as a regressor in another (see, e.g., Hamao et al. (1990)).

<u>The *vech representation*</u>. Given an $N\times1$ vector of returns $\mathbf{R}_t = (R_{1t},\dots,R_{Nt})'$ and supposing $\mathbf{R}_t|\Omega_{t-1} \sim N(\mathbf{m},\mathbf{H}_t)$, where $\boldsymbol{m}$ is an $N\times1$ vector of means, and $\mathbf{H}_t$ is an $N\times N$ variance-covariance matrix. To model the conditional variance we use:

$$\mathrm{vech}(\mathbf{H}_t) = \mathrm{vech}(\mathbf{C}) + \sum_{q=1}^{Q} \mathbf{A}_q \mathrm{vech}(\mathbf{e}_{t-q}\mathbf{e}'_{t-q}) + \sum_{p=1}^{P} \mathbf{B}_p \mathrm{vech}(\mathbf{H}_{t-p}), \tag{5.12}$$

where the 'vech(.)' notation is the 'vector-half ' column stacking operator for the elements in the lower triangle of a symmetric matrix, $\mathbf{e}_t = (\varepsilon_{1t},\ldots,\varepsilon_{Nt})'$ is a vector of return innovations, $\mathbf{C}$ is an $N \times N$ positive definite matrix (a restriction to ensure positive variance), and $\mathbf{A}_q$ and $\mathbf{B}_p$ are $N(N+1)/2 \times N(N+1)/2$ matrices. The problem with this specification is that the number of parameters to be estimated is large even when considering only two time series and one lag, i.e., N = 2, p = q = 1. The model is represented as[41]:

$$\text{vech}(\mathbf{H}_t) = \begin{bmatrix} h_{11,t} \\ h_{12,t} \\ h_{22,t} \end{bmatrix} = \begin{bmatrix} c_{11} \\ c_{12} \\ c_{22} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} \varepsilon^2_{1,t-1} \\ \varepsilon_{1,t}\varepsilon_{2,t-1} \\ \varepsilon^2_{2,t-1} \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \begin{bmatrix} h_{11,t-1} \\ h_{12,t-1} \\ h_{22,t-1} \end{bmatrix}$$

where c_{ij} are constants, and i,j = 1,...,N. There are 21 parameters to be estimated where $\mathbf{A}_q$ and $\mathbf{B}_p$ each has $[(N(N+1))/2]^2$ parameters instead of the N^4 under the true *vec representation.* Each element of the matrix $\mathbf{H}_t$, e.g., $h_{11,t}$, which represents the conditional variance of the first asset, is a function of the square of its own lagged forecast error and that of asset 2, as well as of the cross product of the error terms of the two assets. Additionally, the conditional variance of asset 1 depends on its own lagged conditional variance, that of asset 2 and the covariance between them. This model can be further restricted to a *diagonal representation* by diagonalizing matrices $\mathbf{A}_q$ and $\mathbf{B}_p$, in which case the cross-market interactions are removed.

[41] This is the same *vec representation* illustrated in Model (2.1) of Engle and Kroner (1993), where although they give a *vec equation* they present a *vech* illustration, after removing superfluous covariance elements and the associated coefficients from the *vec* model.

The *BEKK representation*. The conditional variance must be positive in any estimation. This is difficult to impose on the previous model, even in the diagonalized case. However, the *BEKK* model (Engle and Kroner (1993), formerly Baba, Engle, Kraft, and Kroner (1989)) guarantees positive definiteness of $\mathbf{H}_t$ and provides a more parsimonious representation than the *vech* model. The model is:

$$\mathbf{H}_t = \mathbf{C}'\mathbf{C} + \sum_{q=1}^{Q} \mathbf{A}'_q \mathbf{e}_{t-q} \mathbf{e}'_{t-q} \mathbf{A}_q + \sum_{p=1}^{P} \mathbf{B}'_p \mathbf{H}_{t-p} \mathbf{B}_p \tag{5.13}$$

where $\mathbf{C}$ is an $N \times N$ symmetric, upper-triangle, parameter matrix. The conditional covariance matrix $\{\mathbf{H}_t\}_{ij} = h_{ij,\,t}$ is also symmetric. $\mathbf{A}_q$ and $\mathbf{B}_p$ are $N \times N$ free matrices defined as $\{\mathbf{A}_q\}_{ij} = a_{ij,\,p}$ and $\{\mathbf{B}_q\}_{ij} = b_{ij,\,q}$ where p and q are the appropriate lags. De Santis and Gerard (1996a) propose an even more parsimonious specification of the *BEKK representation* based on obtaining the (irrelevant) constants in $\mathbf{C}$ from the estimates of the ARCH and GARCH coefficients. By assuming that the error between the actual and expected returns on an asset is weakly stationary, they relate $\mathbf{C}$ to the relevant coefficients in the following way: $\mathbf{H}_0 = \mathbf{C}'\mathbf{C} * (\iota\iota' - \mathbf{AA}' - \mathbf{BB}')^{-1}$. Here $*$ represents an 'element-by-element' matrix multiplication and $\mathbf{H}_0$ (the unconditional variance-covariance matrix) is obtained from a two-stage generalized method of moments (GMM) iteration, setting it first equal to the sample covariance of the asset returns and then updating it till convergence. This specification avoids the maximum-likelihood estimation of the additional constants in the $\mathbf{C}$ matrix. Thus, a larger number of assets can be estimated using the multivariate GARCH. The *BEKK representation* of the GARCH(1,1) two-equation system is:

$$\begin{bmatrix} h_{11,t} & h_{12,t} \\ 0 & h_{22,t} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{bmatrix}' \begin{bmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{bmatrix}$$

$$+ \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & \varepsilon_{2,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$$

$$+ \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}' \begin{bmatrix} h_{11,t-1} & h_{12,t-1} \\ h_{21,t-1} & h_{22,t-1} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$$

(Appendix F has a full representation of the three-asset model with dummy variables).

This model guarantees positive definiteness by decomposing the constant matrix into **C`C**. It also nests all the positive definite *diagonal representations* and most of the *vec representations*. The improved parsimony is reflected in the fact that this two-asset system has a total of 11 parameters compared with 21 in the *vech representation*. The *BEKK representation* can be diagonalized, as it "...includes as special cases all possible positive definite linear diagonal models...," by making $\mathbf{A}_q$ and $\mathbf{B}_p$ diagonal. The diagonalized model can then be rearranged by placing the diagonal elements of **A** and **B**, respectively, into column vectors and estimating (a GARCH(1,1)):

$$\mathbf{H}_t = \mathbf{C'C} + \mathbf{aa'} * \mathbf{e}_{t-1}\mathbf{e}'_{t-1} + \mathbf{bb'} * \mathbf{H}_{t-1} \tag{5.14}$$

where $\boldsymbol{a}, \boldsymbol{b}$ are $n\times 1$ vectors, and * is the element-by-element matrix product.

All models are estimated by maximizing the likelihood function and obtaining a variance-covariance matrix of the coefficients which is robust to non-normality in the residuals (the Quasi-Maximum Likelihood (QML) approach), e.g., Bollerslev and Wooldridge (1992). That is, since financial variables are usually not normally distributed an adjustment is made to the standard errors obtained from maximizing the Gaussian loglikelihood function. The QML estimators are consistent and asymptotically normal under certain regularity conditions with variance-covariance matrix equal to $\mathbf{D}^{-1}\mathbf{S}\mathbf{D}^{-1}$, where $\mathbf{D}$ is the negative of the expectation of the Hessian and $\mathbf{S}$ is the expectation of the cross-product of scores. The robust standard errors are obtained from the square root of the elements of $T^{-1}\hat{\mathbf{D}}_T^{-1}\hat{\mathbf{S}}_T\hat{\mathbf{D}}_T^{-1}$, where T is the number of observations and the matrices are the estimates of those defined above. The algorithm used to maximize the likelihood function is the Broyden, Fletcher, Goldfarb, and Shanno (BFGS) instead of the popular Berndt, Hall, Hall, and Hausman (BHHH) (1974). The sample log likelihood for each period t, is:

$$L_t(\Phi) = -\tfrac{1}{2}\log\left|\mathbf{H}_t(\Phi)\right| - \tfrac{1}{2}\varepsilon_t'(\Phi)\mathbf{H}_t^{-1}(\Phi)\varepsilon_t(\Phi) \tag{5.15}$$

and over the sample period

$$L(\Phi) = \sum_{t=1}^{T} L_t(\Phi) \tag{5.16}$$

where $\mathbf{\Phi}$ is the vector of conditional mean and conditional variance parameters.

III. Mean-Variance Spanning

III. A. Introduction

The primary technique employed in the second empirical chapter is mean-variance spanning. This is a multivariate test of asset pricing motivated by the mathematics of the mean-variance efficient set (e.g., Roll (1977)) and, in particular, the *k-fund separation principle*. The roots of its derivation are in Shanken (1986) and Huberman and Kandel (1987). Different formulations of the test have been used by several authors. For instance, Bekaert and Urias (1995) motivate a version of the test using the canonical asset-pricing model and the relation between mean-variance frontiers and the Hansen-Jagannathan (H-J, 1991) bounds. H-J bounds use the mean and variance of a sample of assets to restrict the first two moments of the stochastic discount factor (pricing kernel).

The model by Bekaert and Urias (1995) builds on a methodology developed in De Santis (1994, 1995); Harvey (1994a), and Jobson and Korkie (1989) adopt the CAPM framework; Ferson, Foerster, and Keim (1993) demonstrate that the latent-variable asset pricing model can be restricted to be consistent with the null hypothesis imposed under mean-variance spanning, while Ferson (1995) shows the link between the above formulations. De Santis (1997) does a recent review, highlighting in particular the GMM-based estimation of the different tests of mean-variance spanning.

To provide some intuition about mean-variance spanning, consider the case of the APT. Lehman and Modest (1988) note that different exact factor pricing models (of the APT) depend on whether or not the entire mean-variance frontier of a set of securities is well-diversified (which implies mean-variance spanning) or whether only one portfolio on the frontier is well-diversified (implying mean-variance intersection). A *well-diversified portfolio* is one in which, as the number of assets contained therein goes to infinity, the diversifiable (idiosyncratic) risk goes to zero. The APT holds that returns are generated by a linear k-factor model of the following form: $\tilde{R}_{it} = E(\tilde{R}_{it}) + \Sigma_{k=1}^{K} b_{ik} \tilde{F}_{kt} + \tilde{\varepsilon}_{it}$, where $\tilde{R}_{it}$ is the (random) return on asset i, $E(\tilde{R}_{it})$ is its expected return, $\tilde{F}_{kt}$ is the realization of the kth common factor, b_{ik} is the factor loading or sensitivity of asset i to the kth factor, and $\tilde{\varepsilon}_{it}$ is the idiosyncratic return on the ith asset. In the absence of riskless arbitrage opportunities the expected returns on most assets will be: $E(\tilde{R}_{it}) \approx \lambda_{0t} + \Sigma_{k=1}^{K} b_{ikt} \lambda_{kt}$, where λ_0 is an intercept. λ_k is the price of risk for factor k. It is also the expected excess return on a factor-mimicking portfolio - a portfolio with unit sensitivity to the kth factor and zero sensitivity to the other factors (i.e., there is perfect correlation between λ_k and $\tilde{F}_k$). The testable form of the APT replaces the approximation with an exact relation, but traded securities are priced according to the *exact factor pricing* model only if there is a well-diversified portfolio of these assets on the efficient part of their mean-variance frontier.

The three exact factor-pricing models of the APT relate to the type of risk contained in the portfolios that can be formed from a large (infinite) set of risky assets, when each asset is priced by a linear factor model. Such portfolios can contain no factor or idiosyncratic risk, both types of risks, or only factor risk. If one can form a portfolio of infinitely many risky assets (a limiting minimum-variance portfolio) which has a constant return (has no systematic or idiosyncratic risk), then λ_0 is the return on the risk-free asset. In this case, there is also a well-diversified mean-variance efficient portfolio of the K factor-mimicking portfolios that (only) when combined with the risk-free asset will span the mean-variance efficient frontier formed by the individual risky assets. If, however, a large number of the assets in consideration are identically affected by the realization of a factor (such as unanticipated changes in industrial production or oil price), then their factor sensitivities, say b_{i1}, to that factor (e.g., factor one) will be equal. This condition precludes the formation of such a constant-return portfolio and leads to the other two exact factor pricing models. In the first case, if the limiting minimum-variance portfolio is well-diversified (contains only factor risk), then the entire mean-variance efficient frontier of the assets will be well-diversified. The upshot of this is that the K factor-mimicking portfolios will span the frontier of the assets under consideration. This is mean-variance spanning, in which case λ_0 is zero (see F test below). On the other hand, if the limiting minimum-variance portfolio contains some diversifiable risk, then the K factor-mimicking portfolios will not span the efficient frontier of the assets.

III. B. Mean-Variance Spanning: An *F* Test

An efficient portfolio is one in which every constituent security obeys the *beta pricing model*; i.e., there is a positive linear relation between each security's expected returns and it's beta, where the beta is formed relative to the efficient portfolio returns (e.g., see Roll (1977), Ferson (1995)). The test of whether or not a portfolio is efficient falls into the general framework of deducing whether or not we can construct an efficient portfolio from a subset of a larger set of assets (Shanken (1986)). In other words, whether a portfolio of K assets is efficient with respect to a larger set of N assets. This is equivalent to whether or not the efficient frontier spanned by the K assets coincides with the frontier formed from the N assets, where $K \subset N$. This latter case is consistent with the principle of *K-fund separation* (see Constantinides and Malliaris (1995) for a review) which states that the entire minimum-variance frontier traced out by the portfolios from a set of assets can be replicated by the appropriate combination of a subset of K distinct portfolios on the efficient frontier. If we take a set of assets and trace out an efficient frontier, then a subset of those assets (called the spanning assets or the factor-mimicking assets) will form a boundary which lies either on the inside (to the right) of the first boundary, intersects at one point only with the first boundary, or intersects at two or more points. If the latter occurs, then the two boundaries have to coincide and this is termed *mean-variance spanning*. In the case where the boundaries touch once, *mean-variance intersection* is said to exist. If the frontier of the subset of assets falls to the right of the frontier of the full set of assets, then the latter mean-variance dominates the subset; i.e., the subset is not mean-variance efficient.

Tests of mean-variance spanning and intersection are tests of asset performance (see Jobson and Korkie (1989)). Mean-variance spanning tests can be used to evaluate the performance of a portfolio (and by extension a portfolio manager), to assess the diversification benefits of investing in additional assets (e.g., adding small capitalization stocks to investments in the S&P 500, or adding international assets to a domestic portfolio), and also to judge the impact of foreign currency hedging on internationally diversified portfolios (De Santis (1995)). Intuitively, these tests tell an investor if portfolios from a subset of assets mean-variance dominate portfolios from a larger set of assets. If mean-variance spanning exists, then the full set of assets (the limiting minimum-variance portfolio) must be well-diversified, containing only systematic (factor) risks and, hence, having a well-diversified efficient frontier. As a result, we can form as many as K portfolios (from the subset of assets) equivalent to the number of common factors underlying the return-generating process of the set of assets, which will be sufficient to span the mean-variance frontier of the larger set of assets.

Let $\mathbf{R}$ be an $N\times1$ vector of observed asset returns which form the combined opportunity set of the total set of N assets, and trace out a mean-standard deviation frontier from these assets by minimizing the variance-covariance matrix of the asset returns for any given level of realized return. If the mean-standard deviation frontier of a subset K assets were to coincide with that of the N assets, then we conclude that the level of diversification provided by the additional N-K assets is not significantly different from zero. We ascertain the above by defining R_1 as the $K\times1$ vector of returns on the spanning assets and $\mathbf{R}_2$ as the $(N\text{-}K)\times1$ vector of returns on the remaining N-K assets and test the null hypothesis that $\mathbf{R}_1$ spans $\mathbf{R}$.

Consider the following linear model:

$$\mathbf{R}_{2,t} = \mathbf{a} + \mathbf{B}\mathbf{R}_{1,t} + \mathbf{e}_{2,t} \tag{5.17}$$

where **a** and $\mathbf{e}_{2,t}$ are N-K vectors, and B is an $(N\text{-}K)\times K$ matrix of coefficients. Imposing orthogonality conditions $\mathrm{E}(\mathbf{e}_{2,t}) = \mathbf{0}$, where **0** is the null vector of appropriate dimension, Huberman and Kandel (1987), show that mean-variance spanning exists when the following restrictions hold:

H_{01}: The minimum-variance frontier of the subset $\mathbf{R}_1$ *spans* the frontier of the set **R**:

$$\mathbf{a} = \mathbf{0} \text{ and } \mathrm{B}\iota_K = \iota_{N\text{-}K} \text{ or } \sum_{j=1}^{K} b_{ij} = 1, \quad i = K+1,\ldots, N, \tag{5.18}$$

where ι_K is the K-dimension unit vector.

Intuitively, mean-variance spanning can be visualized by comparing the slope of a line drawn from the average return on the zero-beta (or risk-free) rate in mean-standard deviation space tangential to the frontier of the subset of assets $\mathbf{R}_1$ with the slope of a similar line when it is tangential to the frontier of the full set of assets **R**. In the above model, if normality and homoscedasticity characterize the innovations $\mathbf{e}_2$, then an F test is used to measure the significance of the distance between these two lines. A statistically significant distance indicates that the slopes are not equal, hence, the subset $\mathbf{R}_1$ does not span the full set **R**. In other words, adding the N-K assets to the K assets increases the reward-to-risk trade-off (diversification). The test statistic for the case where there is no risk-free asset is:

$$\Phi_z = \frac{(T-N-1)}{(N-K-1)} \frac{(\hat{\mathbf{a}}_z - \hat{\mathbf{a}}_{z1})}{(1+\hat{\mathbf{a}}_{z1})} \tag{5.19}$$

where $\hat{\mathbf{a}}_z = (\bar{\mathbf{r}} - \bar{r}_z\iota)'\mathbf{V}^{-1}(\bar{\mathbf{r}} - \bar{r}_z\iota)$, $\quad \hat{\mathbf{a}}_{z1} = (\bar{\mathbf{r}}_1 - \bar{r}_z\iota_1)'\mathbf{V}_{11}^{-1}(\bar{\mathbf{r}}_1 - \bar{r}_z\iota_1)$,

$\bar{\mathbf{r}}_z = (\hat{\mathbf{b}} - \hat{\mathbf{b}}_1)/(\hat{\mathbf{c}} - \hat{\mathbf{c}}_1)$, $\hat{\mathbf{b}} = \bar{\mathbf{r}}'\mathbf{V}^{-1}\iota$, and $\hat{\mathbf{c}} = \iota'\mathbf{V}^{-1}\iota$

and $\bar{\mathbf{r}}$ represents the vector of mean returns on the **R** assets, $\bar{r}_z$ is the mean return on the zero-beta asset, ι is the unit vector, and **V** is the variance-covariance matrix of all assets. In large samples, the Φ_z statistic has an *F* distribution with (*T*-*N*-1) and (*N*-*K*-1) degrees of freedom, (where *T* is the number of return observations), if the null hypothesis, H_0: $\hat{\mathbf{a}}_z = \hat{\mathbf{a}}_{z1}$, holds.

Noting that definitions with a subscript '1', e.g., $\hat{\mathbf{a}}_{z1}$, relate to the subset of assets $\mathbf{R}_1$ and those without relate to the full set **R**, the Φ_z test has an intuitive appeal. $\hat{\mathbf{a}}_z$, $(\hat{\mathbf{a}}_{z1})$ is the square of the excess returns of the full set (subset) of assets over the zero-beta return weighted by the inverse of the variance-covariance matrix of the full set (subset) of assets; i.e., the square of the excess return per unit of risk (the mean-standard deviation ratio). Weighting the excess return by the variance-covariance matrix serves to determine if the excess returns are merely sampling errors or if they are significant. The numerator of Φ_z reflects the difference between the squared reward-to-risk ratio of the full set of assets and the subset.

III. C. Mean-Variance Intersection

Ferson, Foerster, and Keim (1993) state that the restriction underlying mean-variance intersection is much less stringent than that of mean-variance spanning. Mean-variance intersection is obtained under the following conditions:

H_{02}: The minimum-variance frontier of the subset $\mathbf{R}_1$ *intersects* that of the set $\mathbf{R}$.

In the case where there is no risk-free asset equation (5.17) implies the following:

$$\mathbf{a} = \gamma_0[\iota_{N-K} - \mathbf{B}\iota_K], \tag{5.20}$$

allowing us to write equation (5.17) in "excess return" format where the restriction becomes explicit:

$$\mathbf{R}_{2t} - \gamma_0\iota_{N-K} = \varphi(\gamma_0) + \mathbf{B}(\mathbf{R}_{1t} - \gamma_0\iota_K) + \mathbf{e}_{2t} \tag{5.21}$$

Here γ_0 is a constant equivalent to the expected return on any portfolio of $\mathbf{R}$ with returns that are not correlated with the returns on $\mathbf{R}_1$, and which is on the minimum-variance frontier of $\mathbf{R}$, (a minimum-variance "zero-beta portfolio", where beta is with respect to $\mathbf{R}_1$). ι_K is the K-dimension unit vector, and $\varphi(\gamma_0)$ is a vector of regression intercepts, which is a function of γ_0. The coefficient and the innovation vectors are invariant to γ_0. If mean-variance intersection holds, then the minimum variance frontier of all the asset returns, **R**, and the frontier of the spanning portfolios, $\mathbf{R}_1$, touch at one point only. That is, one combination of the portfolios in the subset $\mathbf{R}_1$ lies on the mean-variance frontier of the full set of assets, **R**.

Normality and homoscedasticity are unlikely to be found in the emerging markets, particularly using high-frequency data (e.g. De Santis (1994)). Rejection of mean-variance spanning may result from a breach of these assumptions. To correct for this potential problem a heteroscedasticity-consistent covariance matrix can be used with the *F* test (e.g., Harvey (1994a)), or the model can be estimated using the generalized method of moments (GMM, Hansen (1982)). The GMM is a nonparametric methodology that is robust to the violation of the assumptions of normality, and the variance-covariance matrix of coefficients can be made homoscedasticity-, and autocorrelation-consistent.

Furthermore, the above derivation of mean-variance spanning is unconditional as it does not utilize available market information to form expectations about the returns on the assets. With increasing evidence of time-varying expected returns (see, among several others, Ferson and Korajczyk (1995)) and time-varying integration of emerging markets (e.g., Bekaert and Harvey (1994)), the GMM-based test is more appropriate. Additionally, conditioning the model on information available to the investor assumes that an actively managed portfolio strategy is being employed[42].

[42] Grinblatt and Titman (1995) assess the performance of actively-managed portfolios.

III. D. Mean-Variance Spanning: The Latent Variables Approach

Ferson, Foerster, and Keim (1993) generalize the latent-variables model (LV model) of asset pricing and shows that it is consistent with the mean-variance spanning model of Huberman and Kandel (1987). The LV model captures in a parsimonious manner the time-varying expected returns of assets using fixed beta coefficients and expected risk premia (prices of risks) which are common across assets. The expected risk premia are the unobserved latent variables (Gibbons and Ferson (1985)). The following specification, which is consistent with the asset-pricing models of Sharpe (1964), Lintner (1965), Black (1972), Merton (1973), and others, is an LV model:

$$E(R_{i,t}|\Omega_{t-1}) = \left[1 - \sum_{h=1}^{K} b_{ih}\right] E(\lambda_{0,t}|\Omega_{t-1}) + \sum_{h=1}^{K} b_{ih} E(\lambda_{h,t}|\Omega_{t-1}), \qquad (5.22)$$

where $\lambda_{h,t}$ is one of the K unobserved ex-post risk premia (per unit compensation for exposure to the h^{th} common factor); b_{ih} is the asset-specific measure of risk (quantity of exposure to the factor), beta, of security i relative to the risk factor h, conditional on the information set $\mathbf{\Omega}_{t-1}$; and $\lambda_{0,t}$ is the return on a zero-beta (or conditionally risk-free) security. If we rewrite equation (5.22) in excess-return form, noting that we can take returns in excess of any asset, not necessarily the risk free asset, e.g., the j^{th} asset R_{jt} we get:

$$E(r_{i,t}|\Omega_{t-1}) = \sum_{h=1}^{K} \beta_{ih} E(\lambda^{*}_{ht}|\Omega_{t-1}), \qquad i = 2,\ldots, N \qquad (5.23)$$

where $r_{it} = (R_{it} - R_{jt})$ is the return on the ith asset in excess of the return on the jth asset, $\beta_{ih} = (b_{ih} - b_{jh})$ is the 'excess' conditional beta, the difference between the beta of asset i and asset j, and $\lambda^*_{ht} = (\lambda_{ht} - \lambda_{0t})$ is the risk premia in excess of λ_{0t}, the returns on the zero beta or conditionally risk-free asset. Write the excess return r_t as an $(N\text{-}1)\times1$ vector and λ^*_{ht} as a $K\times1$ vector and for notational simplicity rewrite equation (5.23) as:

$$E(\mathbf{r}_t | \Omega_{t-1}) = \mathbf{B}E(\lambda^*_t | \Omega_{t-1}) \ , \tag{5.24}$$

where $\mathbf{B}$ is an $(N\text{-}1) \times K$ matrix of fixed coefficients.

Partition $\mathbf{r}_t$ into $\mathbf{r}_t = [\mathbf{r}'_{1,t} \ \ \mathbf{r}'_{2,t}]'$ where $\mathbf{r}_{1,t}$ is a $K \times 1$ vector of *spanning assets* and $\mathbf{r}_{2,t}$ is an $(N\text{-}K\text{-}1) \times 1$ vector of *test assets*. $\mathbf{B}$ is similarly partitioned into $\mathbf{B} = [\mathbf{B}'_1 \ \ \mathbf{B}'_2]'$ where $\mathbf{B}_1$ is a $K\times K$ non-singular (invertible) matrix and $\mathbf{B}_2$ is an $(N\text{-}K\text{-}1) \times K$ matrix. The first K equations of the N-1 equation system in equation (5.24) can be written as:

$$E(\mathbf{r}_{1,t} | \Omega_{t-1}) = \mathbf{B}_1 E(\lambda^*_t | \Omega_{t-1}) \ , \tag{5.25}$$

and the last N-K-1 equations as:

$$E(\mathbf{r}_{2,t} | \Omega_{t-1}) = \mathbf{B}_2 E(\lambda^*_t | \Omega_{t-1}) \ . \tag{5.26}$$

From equation (5.25) we get $E(\lambda_t^* | \Omega_{t-1}) = \mathbf{B}_1^{-1} E(\mathbf{r}_{1,t} | \Omega_{t-1})$ which when substituted into equation (5.26) gives the following relation between the fixed (beta) coefficients:

$$E(\mathbf{r}_{2,t} | \Omega_{t-1}) = \mathbf{B}_2 \mathbf{B}_1^{-1} E(\mathbf{r}_{1,t} | \Omega_{t-1}) \ . \tag{5.27}$$

We can rewrite equation (5.26) without the excess returns as:

$$E(\mathbf{R}_{2,t} | \Omega_{t-1}) = \left[\iota_{N-K-1} - \mathbf{B}_2 \mathbf{B}_1^{-1} \iota_K\right] E(\mathbf{R}_{j,t} | \Omega_{t-1}) + \mathbf{B}_2 \mathbf{B}_1^{-1} E(\mathbf{R}_{1,t} | \Omega_{t-1}) \ . \tag{5.28}$$

If mean-variance spanning holds then the term [.] is zero and the coefficients of the last term add to one for each of the assets of $\mathbf{R}_2$. This equation can then be written in a form similar to that of Huberman and Kandel (eq. (5.17) above), where we omit the constant term:

$$\mathbf{R}_{2,t} = \mathbf{B}\mathbf{R}_{1,t} + \mathbf{e}_{2,t} \tag{5.29}$$

and where

$$\sum_{j=1}^{K} b_{ij} = 1 \qquad \text{for } i = K+1, \ldots, N \qquad \text{and} \qquad E(\mathbf{e}_{2,t} | \Omega_{t-1}) = 0 \, . \tag{5.30}$$

Thus the generalization of the LV model can be restricted to obtain mean-variance spanning.

Chapter 6. "Reverse" Volatility Spillover in the Mexican ADRs Market: Implications for Market Integration

This paper investigates the intra-market feedback between the mean and volatility of the Mexican American depositary receipts (ADRs) and their underlying stocks. The cross-market dynamics between an emerging market and its depositary receipts have not been previously investigated, yet they have several implications for market integration, for trading strategies, for international portfolio diversification, and for the regulation of emerging markets.

In fully integrated markets the ADRs and their underlying stocks are perfect substitutes, representing one asset based on the same cash-flows but trading in two markets (e.g. Alexander et al. (1987,1988)). Hence, any lagged mean and volatility spillovers between the ADRs and their underlying stocks (denoted *reverse spillovers* in this paper) are inconsistent with market integration[43]. As there is mixed support for the hypothesis that the Mexican market is integrated with the international capital markets (e.g., Bekaert and Harvey (1994) and Korajczyk (1995)), this study provides new (albeit indirect) evidence. Second, significant reverse mean spillovers between ADRs and their underlying stocks could be an indication of the existence of profitable arbitrage even in the more liquid end of the market. Domowitz, Glen, and Madhaven (1996, 1997) indicate that there are arbitrage possibilities between Mexican over-the-counter (OTC) and Rule 144A depositary receipts and their underlying stocks. Finally, as there are now traded options on several Mexican ADRs and Mexican index futures

[43] If the Mexican market is integrated, then the ADRs and their underlying stocks should yield the same expected dollar returns (or prices), regardless of the fact that they trade in different markets (Stulz (1981)). Both assets should also impound relevant market information at the same rate. Thus there should be no lagged spillovers between them.

contracts, an understanding of the relation between the ADRs and their underlying assets can enhance investors' pricing and hedging strategies and could lead to improved regulation of these securities.

Several papers have considered the inter-market transmission of securities price changes around the globe. Accumulated empirical evidence strongly suggests that not only are there strong price co-movements between the major international stock and currency markets[44], but also that price changes are transmitted between the more developed markets and the emerging markets (EMs), e.g., from Japan to Korea (Kim and Rogers (1995)), between different sections of the same market, e.g., from large firms to small firms (Francis and Hasan (1998), Conrad, Gultekin, and Kaul (1991)), between stock index and the index futures (e.g., Chan (1992), Stoll and Whaley (1990a)), and between equities and currency markets (Francis and Hunter (1998)).

This study adds to the literature in international finance by focusing on three issues. In the first test the proposition that Mexican ADRs behave more like US than like Mexican assets is examined. Chang, Eun, and Kolodny (1995)[45] and others note that closed-end country funds (CECFs) are significantly exposed to US factors and behave more like US securities even though they are influenced by home-country factors. This observation can be explained by partial integration (see Errunza and Losq (1985a), Errunza, Losq, and Padmanabahn (1992)) of the markets for country funds.

[44] For equities see Francis and Leachman (1996), Karolyi (1995), Kim and Rogers (1995), King, Sentana, and Wadhwani (1994), Susmel and Engle (1994), Lin et al. (1994), Engle and Susmel (1993), and Hamao, Masulis, and Ng (1990); for foreign exchange see Bollerslev (1990), Baillie and Bollerslev (1990), and Engle, Ito, and Lin (1990).

[45] See Eitman and Stonehill (1989) for evidence on other assets. Urias (1996) finds that Chilean ADRs are priced more like US assets than is predicted by his model. However, imprecision in his estimation and the very small sample size rule out any generalization about Chilean ADRs.

Given the evidence of time-varying integration of the EMs (Bekaert and Harvey (1994)), their ADRs might be expected to behave in a similar manner. Moreover, cross-listed stocks tend to become integrated with the host market, since as Stapleton and Subrahmanyam (1977) and Howe and Madura (1990) argue, those firms which are relatively large and which engage in exports to the US are more likely to list shares in the US. Furthermore, these firms tend to take other actions to mitigate the effects of segmentation, including overseas mergers and acquisitions of other firms. Also, Alexander, Eun, and Janakiramanan (1987) state that there is an "externality effect" whereby cross-listed stocks aid in the integration of the entire market. If the above arguments are true, then one would expect to see ADRs acting more like US securities. Evidence that these arguments may be true can be inferred from Karolyi (1995) who finds that the mean of the Canadian cross-listed stocks depend more on the one-day lagged mean of the S&P 500 (coefficient = 0.116) than on the lagged TSE 300 (Canadian) index (coefficient = 0.058).

The second test examines the feedback between the ADRs and their underlying stocks. Using US stocks interlisted in London, Neumark, Tinsley, and Tosini (1991) state that the London prices of these securities formed after the close of the NYSE "...do not appear to be fully transmitted to *opening* New York prices,..."; i.e., the depositary receipts seem not to influence the mean and volatility of their underlying stocks[46]. The authors argue that this conforms with rational investor behavior since

[46] Werner and Kleidon (1996) find that as NYSE opening approaches, the volatility (in London) of British stocks with ADRs, as well as that of the rest of the market, increases and that volatility remains high during the period of the overlap of the London and New York markets. Additionally, a large portion of the volatility of British ADRs is generated in this period. Dismissing the notion of price discovery for the ADRs, since their underlying have been trading for some time before in London, one possibility is that there is (contemporaneous) transmission of volatility from London to New York which is picked up by the ADRs.

the price changes of the depositary receipts were not large enough to break the veil of transaction costs of trading in the home market on the basis of information in the prices of the depositary receipts. This argument is similar to that of Goldman and Sosin (1979), who suggest that investors pool their information until it is profitable to trade, given market frictions such as transaction costs. Neumark et al. incorporated transaction costs in their model and showed that, for a given cost, the extent to which foreign prices are reflected in home prices depends on the volatility of the foreign prices. As the volatility of the Mexican ADRs is greater than that of their underlying and other local stocks, the probability of contemporaneous spillovers and interdependence is increased. However, if the Mexican market is internationally integrated, then there should be no *reverse* spillovers as a result of higher volatility in the market for ADRs. The test is then modified to remove any impact of exchange rates on the results.

The third test examines the issue of regional contagion between the Mexican and other Latin American ADRs. Currency fluctuations characterize economies of many emerging markets and have caused large swings in (dollar) equity values over short periods. Bailey, Chan, and Chung (1998) find that during the Mexican crisis of December 1994 the lagged peso/dollar changes and volatility significantly spilled over onto the return and volatility of the Mexican and non-Mexican ADRs, but this reflected the information in exchange rate changes rather than any panic reaction. They find no contagion in the Latin American region nor throughout the rest of the emerging markets. However, others argue that the peso crash led to declines in the markets of Argentina, Brazil, Chile, Colombia, and Venezuela in the first 10 days after the devaluation and into the first quarter of 1995, though there is less certainty of its effects on the Asian markets since, individually, they moved in different directions during the first quarter of 1995 (IMF (1995)).

I find that the ADRs act more like Mexican assets than like American securities. This is inconsistent with the full integration of the Mexican market. Second, there are significant reverse spillovers in the Mexican market, even after orthogonalizing the returns on the ADRs and on the underlying stocks to the changes in the peso/dollar exchange rate. Third, I find that there is only limited evidence of spillover between the Mexican and non-Mexican ADRs.

The remainder of this paper contains five sections. Section I briefly reviews aspects of the literature. Section II outlines the methodology and Section III describes the data and preliminary analyses. Section IV presents the results and the paper's summary and conclusions are in Section V.

I. Literature Review

Lin, Engle, and Ito (1994) state that as markets become more integrated, the level of correlation between their stock returns increases[47] since portfolio managers become

[47] Errunza (1994) points out that closer integration need not result in increased correlation since, e.g., not all the stocks on the NYSE (considered integrated) are highly correlated. Professor Campbell Harvey (at FMA Conference (1997)) suggested further that it would be reasonable to consider that many of the EMs are becoming more integrated with time yet the level of correlation between them is low and has been so over the last several years. Furthermore, increased volatility leads to improved international correlation but the latter may not necessarily reflect a growth in international market integration, but rather a transitory occurrence. It is worth noting also that economic integration need not lead to greater financial integration. See also Adler and Dumas (1983) for a discussion.

more responsive to foreign-market signals. Susmel and Engle (1994) posit that if listed companies are multinational in organization and function, then shocks to fundamentals in one part of the world will reverberate in other parts even when they are geographically far removed. The reactions to shifts in fundamentals will occur simultaneously in those markets that are open and will be captured in the opening prices of those that open subsequently. These observations are consistent with models of international asset pricing and market efficiency[48], since international systematic factors will simultaneously (though not necessarily to the same extent) affect the markets. Hamao, Masulis, and Ng (1990) suggest that where two integrated markets trade sequentially, the price changes in the first market to open will spill over into the close-to-open returns of the next market to open. There is no reason, a priori, for the price changes of the first market to affect the open-to-close return of the second, since if the latter is informationally efficient then its opening prices should incorporate all the news reflected in the prices of the first market.

The use of intra-day data to investigate interdependency between markets that trade sequentially allows researchers to "...measure more accurately the 'volatility spillover' from one market to another by examining only those cases where the opening occurs in a market *after* close in another market." Roll (1989, p. 222). Where two integrated and informationally efficient markets trade concurrently, the past return and volatility of one market will not impact on the current return and volatility of the other. Any

[48] For international asset pricing see, e.g., Solnik (1974a, b, 1983), Stulz (1981a, b, 1985), Adler and Dumas (1983), Errunza and Losq (1985a), Cho, Eun, and Senbet (1986), Ikeda (1991). Stulz (1994) has a survey. Market efficiency is covered by Fama (1965, 1970, 1991), and LeRoy (1989).

relevant public information impounded into the prices of one market will simultaneously be reflected by the other.

Studies using intra-day data (close-to-open and open-to-close) generally obtain the opening bid/ask quotes or transaction prices within 15 minutes of the market opening to avoid too many stocks experiencing multiple trades before the index is sampled. However, Lin et al. (1994) find that sampling the data too early, even in the very active US and Japanese markets, causes a bias towards finding significant spillovers. Stoll and Whaley (1990b) show that most NYSE stocks do trade within the first 15 minutes after opening. Price changes that have been limited by circuit-breaker rules are removed from the sample since these are not equilibrium prices[49]. While the use of daily data increases the chance of observing transient inter-market price movements, it introduces additional considerations such as accounting for day-of-the-week and holiday effects (e.g., French (1980), Jaffe and Westerfield (1985)) and treating excess autocorrelation[50].

[49] Perhaps the first price after the resumption of trading should also be removed since it is not clear, according to Stoll and Whaley (1990b), that the procedure for halting trade ensures that the next price will reflect the true value of the security.

[50] The cause of most of the autocorrelation in the EMs is likely to be nontrading (and non-synchronous trading), with a common market factor, speed of information processing by market participants, day-of-the-week effect (see Akgiray (1989)), bid-ask bounce, price rounding, and the imposition of a ceiling on price changes (see Kim and Rogers (1995)) as secondary factors. The positive (negative) autocorrelation in the returns on stock indices (individual stocks) is a well documented fact dating back at least to Fama (1965) and Fisher (1966). The papers by Cohen, Hawawini, Maier, Schwartz and Whitcomb (CHMSW) (1980, 1983a, b) and CMSW (1978, 1979, 1986) deal comprehensively with the observed phenomenon, its causes, and consequences. Others such as Scholes and Williams (1977) and Dimson (1979) have developed methods of overcoming the effects of autocorrelation on measuring systematic risk (beta), while several authors like Jokivuolle (1995), Stoll and Whaley (1990a), Blume, MacKinlay, and Terker (1989), and Harris (1989) attempt to correct for autocorrelation in the index by estimating the 'true' unobserved index. Lo and MacKinlay (1990) note that a significant portion of autocorrelation in the (NYSE) index may not be the result of nonsynchronicity. Cutler, Poterba, and Summers (1991) assert that nontrading could not be the cause of the autocorrelation they find in markets for foreign exchange, gold, and bonds. But the fact that futures markets tend to be less autocorrelated than spot markets lends support to the nontrading explanation. Roll (1981) notes that the autocorrelation is spurious, merely a consequence of the way records of prices are kept and updated.

While the majority of researchers attribute increased spillover between stock markets to growing correlation and increased integration, King and Wadhwani (1990) have propounded an alternative logic; that of the *market contagion effect*. Essentially, in a rational expectations equilibrium market, traders faced with asymmetric information are informed of relevant news by price changes provided that the information structure is relatively simple. In this case, there is a fully-revealing equilibrium and prices reflect economic fundamentals. If the information structure is complex and a non-fully-revealing equilibrium exists, then the prices in one market do not reflect only economic fundamentals, but they also incorporate information about changes in stock prices in other markets. Contagion is said to exist, and in this state the pricing "mistakes" in one market are picked up by another. There is evidence that international covariances and spillover between markets are increased at times of major shocks to national markets (e.g., Roll (1989), King and Wadhwani (1990), Arshanapalli and Doukas (1993), Tang (1995), Karolyi and Stulz (1996)), though King, Sentana, and Wadhwani (1994) note that these are mainly transient effects unrelated to increased integration. Gagnon and Karolyi (1997) find that the co-movements of major stock markets are also related to aggregate measures of stock market trading and liquidity, given the relation between the information content of high trade volumes and the autocorrelation of returns.

II. Methodology

II. A. The Multivariate GARCH Model

GARCH[51] models have been applied to the study of mean and volatility transmission by several researchers even though, as pointed out by Susmel and Engle (1994), most studies failed to show mean spillovers. Studies such as Kim and Rogers (1995), Eun and Shim (1989), and Roll (1989) note that as markets become more integrated the spillovers[52] are significant, if only from the US to other markets. However, Lin et al. (1994) and Susmel and Engle (1994) find bi-directional transmission between the US and other markets, especially during the overlap in trading in New York and London.

The multivariate framework is more efficient than its univariate counterpart in capturing bi-directional transmissions and reflects the fact that the markets in the system of equations may be reacting to the same market information and, hence, may have covariances conditional on a common information set. Additionally, unlike the "volatility surprise" first used by Hamao et al. (1990), this method shows the impact of both lagged squared errors and past volatility of one market on the other, which aids in the analysis of the results. Moreover, multivariate models have been successful in reflecting the various aspects of the dynamics of asset returns and volatility (e.g., Bollerslev, Engle, and Wooldridge (1988), Ng (1991), Chan, Karolyi, and Stulz

[51] The ARCH family of statistical models has been used extensively in financial research since its development by Engle (1982) and its generalization by Bollerslev (1986). For a technical note see Engle (1993); for the most important contributions see Engle (1995); for a review of the application of ARCH in finance see Bollerslev, Chou, and Kroner (1992) and Bera and Higgins (1993).

[52] These are contemporary spillovers in the case of markets that trade concurrently, or of close-to-open prices in the case of markets trading sequentially. There should be no lagged spillovers in informationally efficient and internationally integrated markets .

(1992), Karolyi (1995), De Santis and Gerard (1996a, b), De Santis and Imrohoroglu (1996)). The applications in this paper use the parsimonious *BEKK* representation[53] of Engle and Kroner (1993), which guarantees a positive conditional variance.

The most general model employed in this paper is:

$$\mathbf{R}_t = \Psi_0 + \sum_{l=1}^{L} \Psi_l \mathbf{R}_{t-l} + \Pi_1 \mathrm{Hol}_t + \Pi_2 \mathrm{Wknd}_t + \Pi_3 \mathrm{Crash}_t + \mathbf{e}_t$$

$$\text{and} \quad \mathbf{e}_t | \Omega_{t-1} \sim \mathrm{N}(\mathbf{0}, \mathbf{H}_t) \qquad (6.1)$$

$$\mathbf{H}_t = \mathbf{C}'\mathbf{C} + \sum_{q=1}^{Q} \mathbf{A}'_q \mathbf{e}_{t-q} \mathbf{e}'_{t-q} \mathbf{A}_q + \sum_{p=1}^{P} \mathbf{B}'_p \mathbf{H}_{t-p} \mathbf{B}_p + \mathbf{W}'\mathbf{W}\mathrm{Wknd}_t + \mathbf{L}'\mathbf{L}\mathrm{Hol}_t + \mathbf{K}'\mathbf{K}\mathrm{Crash}_t \qquad (6.2)$$

where $\mathbf{R}'_t = (R_{1t}, R_{2t}, R_{3t})$, are, say, the returns on the S&P 500, the Mexican index, and the portfolio of ADRs, respectively; $\Psi'_0 = (\psi_{01}, \psi_{02}, \psi_{03})$, $\{\Psi_l\}_{ij} = \psi_{ij,l}$ where the *i,j*th element of Ψ_l indicates the effect of, say, the portfolio of ADRs on the S&P 500 index in l days. The residuals from the conditional means are $\mathbf{e}'_t = (\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t})$; $\Pi'_1 = (\pi_{11}, \pi_{12}, \pi_{13})$ is a vector of coefficients on the dummy variable (*Hol*) represented by one for mid-week exchange holidays and zero otherwise (e.g., French and Roll (1986)). If one market is closed on a particular day, the other markets are also treated as being closed thus creating simultaneous multiple-day returns in the respective indices. Π_2 is a vector of coefficients on a dummy (*Wknd*) with one representing Mondays and zero otherwise to capture any day-of-the-week effect (e.g., French (1980), Jaffe and Westerfield (1985)). Π_3 is the vector of coefficients on the

[53] De Santis and Gerard (1996a) propose an even more parsimonious representation of the multivariate GARCH based on obtaining the constants in the matrix **C** from the estimates of the ARCH and GARCH coefficients.

crash dummy (*Crash*), with one after the peso crash and zero otherwise, to account for the effect of the crash on the mean and volatility. **C**, **W**, **L**, and **K** are n×n, upper-triangle, parameter matrices. **A** and **B** are free matrices defined as $\{\mathbf{A}_q\}_{ij} = a_{ij,q}$ and $\{\mathbf{B}_p\}_{ij} = b_{ij,p}$ where p and q are the appropriate lags. For the GARCH(1,1), weak stationarity requires that all the eigenvalues of $\mathbf{A}_1 \otimes \mathbf{A}_1 + \mathbf{B}_1 \otimes \mathbf{B}_1$ are less than one in modulus. In this non-diagonal specification, stationarity is not necessarily violated if a particular coefficient is greater than one as all variance and covariance coefficients impact on stationarity.

Model Estimation. Bekaert and Harvey (1995) posit that the returns of emerging markets are highly leptokurtic and skewed, hence, a non-parametric density function such as is used in the semi-nonparametric ARCH (SPARCH) may give better results. However, Engle (1995) notes that the results from the SPARCH are similar to that from GARCH that assumes the normal or student-t distribution, and Engle (1993) states that assuming normality of the conditional density (in the univariate case) does not usually affect the estimates even when the assumption turns out to be false. On the other hand, French, Schwert, and Stambaugh (1987) find that the GARCH-M over predicts volatility in comparison to an ARMA model and suggest that it may be due to the sensitivity of the GARCH-M model to the normality assumption imposed on it by the Maximum Likelihood (ML) estimation. In the multivariate case, De Santis and Gerard (1996a, b), Karolyi (1995), and others maximize the likelihood function using Berndt, Hall, Hall, and Hausman (BHHH) (1974)) algorithm but obtain a variance-covariance matrix of coefficients (Quasi-Maximum Likelihood (QML) approach) which is robust to non-normal errors (e.g., Bollerslev and Wooldridge (1992)). I use the Broyden, Fletcher, Goldfarb, and Shanno (BFGS) algorithm with an equivalent robust variance-covariance matrix, and report robust Wald tests. The sample log likelihood for each period t, is:

$$L_t(\Phi) = -\tfrac{1}{2}\log\left|\mathbf{H}_t(\Phi)\right| - \tfrac{1}{2}\mathbf{e}_t'(\Phi)\mathbf{H}_t^{-1}(\Phi)\mathbf{e}_t(\Phi) \tag{6.3}$$

and over the sample period, T,

$$L(\Phi) = \sum_{t=1}^{T} L_t(\Phi), \tag{6.4}$$

where $\mathbf{\Phi}$ is the vector of conditional mean and conditional variance parameters. Model diagnostics, coefficients, and the graph of the conditional variances are taken into consideration in selecting the final specification. The multivariate version of Schwarz Bayesian Criterion (SBC) is the arbiter where the models are all reasonable with respect to the above criteria.

II. B. The Vector Autoregression (VAR) Specification

Using the VAR model (Sims (1980)), I also report the coefficients and graphs of the standardized impulse responses and the forecast error variance decomposition in order to further characterize the relation between the various markets (e.g., Eun and Shim (1989) and Jeon and von Furstenberg (1990)). Since I use returns (log-price differences) rather than prices, nonstationarity is not a concern. The VAR is modeled as equation (6.1) where the residuals are assumed to be homoscedastic. $\mathbf{e}_t \sim N(\mathbf{0}, \mathbf{W})$, where $\mathbf{W}$ is an n×n constant covariance matrix and $\mathbf{R}_t$ and $\mathbf{R}_{t-l}$ are n×1 and $(n\times l)\times 1$ vectors of the daily and lagged returns on the n indices, respectively. The VAR models the unrestricted reduced-form specification of a set of dependent variables; i.e., the right hand side of each equation contains the same lagged-dependent variables.

The error terms are compound error terms involving cross-market feedback coefficients of one variable to another, however. These are difficult to interpret so a vector moving-average (VMA) representation obtained by back-substitution is usually used. This results in a representation of returns as a linear combination of past one-step-ahead innovations which allows us to trace out the response of one market to unexpected shocks in another:

$$\mathbf{R}_t = \sum_{l=0}^{\infty} \mathbf{B}_l \mathbf{e}_{t-l}\,. \tag{6.5}$$

The i,jth element of $\mathbf{B}_l$ measures the response of the ith market in l periods to a unit random shock in market j but none in the other markets. The error terms, $\mathbf{e}_t$, are serially uncorrelated with zero mean and constant variance, but they may be contemporaneously correlated, thus masking some of the response patterns of the VAR. This is avoided by transforming the errors using the Cholesky factorization in which we obtain a lower triangle matrix, say $\mathbf{V}$, and orthogonalizing the innovations $\mathbf{v}_t = \mathbf{V}^{-1}\mathbf{e}_t$, such that $\mathbf{V}^{-1}\mathbf{W}\mathbf{V}'^{-1} = \mathbf{I}$[54]. The resulting VMA representation is:

[54] We have $\mathbf{v}_t\mathbf{v}_t' = \mathbf{I} = \mathbf{V}^{-1}\mathbf{e}_t'\mathbf{e}_t'\mathbf{V}'^{-1}$ and $\mathrm{E}(\mathbf{e}_t'\mathbf{e}_t') = \mathbf{W}$; i.e., the orthogonalized innovations have an identity variance-covariance matrix.

$$\mathbf{R}_t = \sum_{l=0}^{\infty} \mathbf{B}_l \mathbf{V} \mathbf{v}_{t-l} = \sum_{l=0}^{\infty} \mathbf{C}_l \mathbf{v}_{t-l} . \tag{6.6}$$

The *i,j*th element of $\mathbf{C}_l$ is the *impulse response* of the *i*th market in *l* periods to a shock of one standard deviation in the *j*th market (see Eun and Shim (1989) for further explanation). The elements of **v** directly influence the variance of each element in $\mathbf{R}_t$ and the extent of this influence is captured by the magnitude of $\sum_{l=0}^{T} c_{ij,l}^2$, which is the proportion of forecast error variance in the T+1 step-ahead forecast of R_i accounted for by the innovations of R_j. With this *forecast error variance decomposition* we can attribute the variance of returns in each market to its own innovations and to those of the other two markets. A likelihood ratio (LR) test and the Schwarz criterion are used to select the most parsimonious model. *Block exogeneity* and *block causality tests* support the inclusion of the S&P 500 in the trivariate system.

III. Data and Preliminary Analysis

Data. This paper uses a sample of exchange-listed and over-the-counter ADRs over the period January 1993 to December 1996. Following changes to the opening hours of the Mexican stock exchange in late 1992 it now has simultaneous trading hours with the US stock exchanges. Furthermore, during this period the Latin American ADRs were most actively listed and traded. The data include the daily returns on the Standard and Poor's (S&P 500) Composite Index (SPNDX), an index constructed from the Mexican listed ADRs (MEXADR), and an index of non-Mexican listed ADRs (XMXADR). These data are obtained from the Center for Research in Securities Prices (CRSP) database. All remaining data are obtained from Datastream.

These include a daily Mexican (peso) index (MEXNDX), peso/dollar exchange rates, data to construct indices from the Mexican over-the-counter ADRs (OTCADR), from the underlying stocks of the listed ADRs (MEXUDR), and from the underlying stocks of the over-the-counter ADRs (OTCUDR). All indices are value-weighted and returns are log-price differences. The Datastream index contains a larger number of stocks (90) than the Mexican market index (the IPC (35)), and may, therefore, reflect the broader market more closely. Also, it is not overly influenced by the underlying stocks.

Preliminary Analyses. Figure 6.1 contrasts the large devaluation of the peso on December 20, 1994 (15%) and on December 22, 1994 (21%) with the changes in two Mexican indices, the S&P 500, and the portfolio of listed ADRs. Tables 6.1 and 6.2 compile summary statistics. Only the return on the S&P 500 is significantly different from zero (0.055%, t = 2.76). Both sets of ADRs have larger range and standard deviation of returns than their underlying stocks. This is consistent with the observation that "derivative" assets such as country funds are likely to be more volatile than their underlying securities (Diwan, Errunza, and Senbet (1992)). This is also consistent with notions of excess volatility whereby stock price variability is much greater than the volatility of their underlying cash-flows (dividends) (Summers (1986) and Shiller (1981)). The Shapiro-Wilk (W) test for normality indicates that the returns are not normally distributed.

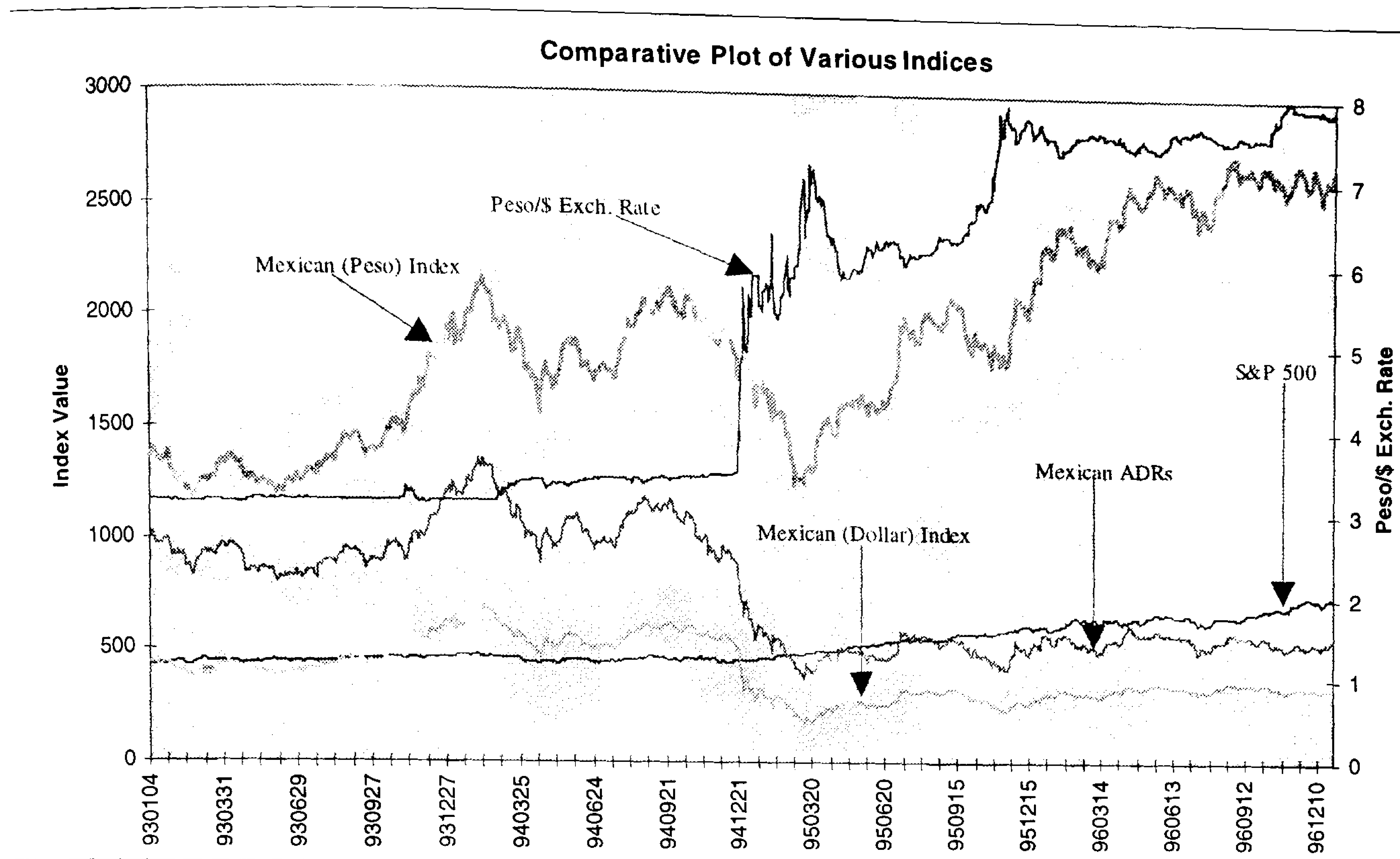


Figure 6.1

Table 6.1 Summary Statistics of Various Indices

	Mexican Peso Index (MEXNDX)			Mexican Dollar Index (MEXdNDX)			S&P 500 Index (SPNDX)		
No. Obs.	973	478	495	973	478	495	973	478	495
Mean %	0.070	0.052	0.088	-0.025	0.031	-0.079	0.055	0.011	0.097
T:Mean=0	1.570	0.872	1.315	-0.337	0.486	-0.596	2.761	0.388	3.404
Std Dev.	1.400	1.038	1.482	2.327	1.391	2.963	0.617	0.595	0.635
Skewness	0.078	-0.127	0.206	-1.670	-0.133	-1.538	-0.415	-0.301	- 0.536
Kurtosis	2.791	1.868	3.031	31.09	1.730	22.31	2.100	1.723	2.480
Pr(Normal)	0.000	0.122	0.000	0.000	0.099	0.000	0.000	0.014	0.000
Min	-6.067	-5.510	-6.067	-26.04	-5.799	-26.04	-3. 131	-2.429	- 3.131
Max	7.310	4.973	7.310	19.39	4.973	19.39	2.112	2.112	1.925
		MEXADR			**MEXUDR**			**OTCADR**	
OTCUDR									
No. Obs.	973	478	495	973	4 78	495		494	494
Mean %	-0.060	-0.032	-0.087	0.039	0.006	0.071		-0.049	0.091
T:Mean=0	-0.863	-0.404	-0.768	0.722	0.078	0.904		0.758	0.423
Std Dev.	2.167	1.714	2.530	1.692	1.622	1.758		3.500	2.525
Skewness	0.560	0.004	0.711	0.091	-0.130	0.251		-0.828	0.313
Kurtosis	6.458	1.542	6.171	1.648	1.539	1.674		14.66	6.896
Pr(Normal)	0.000	0.414	0.000	0.000	0.201	0.000		0.000	0.000
Min	-10.33	-6.948	-10.33	-6.445	-6.445	-6.355		-29.08	-11.72
Max	15.19	6.350	15.19	6.294	5.954	6.294		16.86	15.86

MEXADR are exchange-listed Mexican ADRs, OTCADR are over-the-counter ADRs, MEXUDR and OTCUDR are underlying stocks of the MEXADR and OTCADR, respectively. MEXNDX (MEXdNDX) is the Mexican peso (dollar) index and SPNDX is the S&P 500 index. The three columns under each heading represent the sample periods January 1993 to December 1996, January 1993 to 19 December 1994, and 20 December 1994 to December 1996, respectively, except for the OTCADR and OTCUDR which report data for the last period only.

Table 6.2 shows the results of the autocorrelation and cross-correlation analyses. In Panel A all series except MEXADR have significant first and higher-order autocorrelations. The lack of significant autocorrelation in MEXADR reflects the high liquidity of these securities. In 1995, e.g., they accounted for 19.7% (28.8%) of total dollar trading volume (share trading volume) of all listed depositary receipts, compared with 5.7% (7.2%) for Argentina, 4.2 (3.4%) for Chile, and 24.5% (24.4%) for the UK. In that year, five of the 10 most actively traded ADRs were from the Latin American region (BNY(1996b)). Mexican ADRs such as Telemex average over 2000 trades per day (Bailey et al. (1998)). Furthermore, only in the case of the peso index is autocorrelation larger than that of the Canadian (TSE 300) index used in Karolyi (1995), for instance. In fact, the autocorrelation in the early periods of the TSE 300 are over twice that for most of the indices used in this study. The autocorrelation of the Mexican assets are also less than that of the small European markets (Harvey (1994)). My methodology accounts for autocorrelation, hence, the results are not affected by it.

The squared returns (in Panel B), except for the S&P 500, display autocorrelations that are characteristically larger and more persistent than the autocorrelations in the returns. The Ljung-Box (Q) tests (with p-values generally less than 0.01) suggest that there are ARCH errors in all the series. This was independently confirmed (not reported), even after removing the first 10 days after the peso crash. Panel C indicates that there is generally only contemporaneous cross-correlation between the S&P 500 and the Mexican assets, but there is more lagged dependency between the Mexican index and the ADRs and between the ADRs and their underlying stocks.

Table 6.2 Autocorrelation and Cross-correlation Analyses of Various Indices

Panel A. Autocorrelation Analyses of Indices

SPNDX	MEXNDX	MEXADR	MEXUDR	OTCADR	OTCUDR
Lag Coeff. S.E.	Lag Coeff. S.E.	Lag Coeff. S.E.	Lag Coeff. S.E.	Lag Coeff. S.E.	Lag Coeff. S.E.
1 **0.088** (0.032)	1 **0.182** (0.032)	1 0.049 (0.032)	1 **0.097** (0.032)	1 **0.132** (0.045)	1 **0.1114** (0.045)
2 0.012 (0.032)	2 - 0.006 (0.033)	2 0.003 (0.032)	2 - 0.011 (0.032)	2 **- 0.213** (0.046)	2 - 0.0651 (0.046)
3 **- 0.095** (0.032)	3 - 0.012 (0.033)	3 0.006 (0.032)	3 - 0.023 (0.032)	3 **- 0.102** (0.048)	3 - 0.0479 (0.046)
4 - 0.048 (0.033)	4 0.040 (0.033)	4 0.001 (0.032)	4 0.020 (0.032)	4 0.012 (0.048)	4 0.0112 (0.046)
Q Stat. p-value	Q Stat. p-value	Q Stat. p-value	Q Stat. p-value	Q Stat. p-value	Q Stat. p-value
LB (6) **0.002**	LB(6) **0.000**	LB(6) 0.866	LB (6) **0.092**	LB (6) **0.000**	LB(6) 0.119
LB(12) **0.004**	LB(12) **0.000**	LB(12) 0.626	LB(12) **0.081**	LB(12) **0.000**	LB(12) 0.216
LB(18) **0.011**	LB(18) **0.000**	LB(18) 0.640	LB(18) **0.039**	LB(18) **0.000**	LB(18) **0.099**
LB(24) **0.007**	LB(24) **0.000**	LB(24) 0.565	LB(24) **0.032**	LB(24) **0.000**	LB(24) **0.008**

Panel B. Autocorrelation Analysis of Squared Returns

Squared Returns on SPNDX	**Squared Returns on MEXNDX**	**Squared Returns on MEXADR**	**Squared Returns of MEXUDR**	**Squared Returns on OTCADR**	**Squared Returns on OTCUDR**
Lag Coeff. S.E.	Lag Coeff. S.E.	Lag Coeff. S.E.	Lag Coeff. S.E.	Lag Coeff. S.E.	Lag Coeff. S.E.
1 0.029 (0.032)	1 **0.250** (0.032)	1 **0.159** (0.032)	1 **0.233** (0.032)	1 **0.117** (0.045)	1 **0.3553** (0.045)
2 0.056 (0.032)	2 **0.146** (0.034)	2 **0.154** (0.033)	2 **0.185** (0.034)	2 **0.255** (0.046)	2 **0.1869** (0.050)
3 0.046 (0.032)	3 **0.154** (0.035)	3 **0.064** (0.034)	3 **0.106** (0.035)	3 **0.217** (0.048)	3 **0.1668** (0.052)
4 **0.087** (0.032)	4 **0.124** (0.035)	4 0.051 (0.034)	4 **0.080** (0.035)	4 0.065 (0.050)	4 **0.1477** (0.053)
Q Stat. p-value	Q Stat. p-value	Q Stat. p-value	Q Stat. p-value	Q Stat. p-value	Q Stat. p-value
LB(6) **0.001**	LB(6) **0.000**	LB(6) **0.000**	LB (6) **0.000**	LB (6) **0.000**	LB(6) **0.000**
LB(12) **0.002**	LB(12) **0.000**	LB(12) **0.000**	LB(12) **0.000**	LB(12) **0.000**	LB(12) **0.000**
LB(18) **0.000**	LB(18) **0.000**	LB(18) **0.000**	LB(18) **0.000**	LB(18) **0.000**	LB(18) **0.000**
LB(24) **0.001**	LB(24) **0.000**	LB(24) **0.000**	LB(24) **0.000**	LB(24) **0.000**	LB(24) **0.000**

Panel C. Cross-correlation Analyses Between Various Indices

Lag	**S&P 500 and MEXNDX**	**Squared S&P 500 and MEXNDX**	**S&P 500 and MEXADR**	**Squared S&P 500 and MEXADR**	**MEXADR and MEXUDR**	**Squared MEXADR and MEXUDR**
-3	- 0.062	- 0.048	- 0.070	- 0.029	- 0.000	0.061
-2	0.028	- 0.034	0.011	- 0.042	- 0.009	**0.088**
-1	**0.100**	0.013	0.036	- 0.008	**0.088**	**0.215**
0	**0.262**	- 0.042	**0.317**	**0.076**	**0.750**	**0.509**
1	0.028	0.018	0.032	- 0.046	**0.131**	**0.135**
2	0.006	- 0.033	0.005	0.000	- 0.053	**0.146**
3	0.002	- 0.039	0.006	- 0.007	0.022	**0.075**

Lag	**MEXNDX and MEXADR**	**Squared MEXNDX and MEXADR**	**MEXNDX and OTCADR**	**Squared MEXNDX and OTCADR**	**OTCADR and OTCUDR**	**Squared OTCADR and Squared OTCUDR**
-3	0.044	0.064	**- 0.121**	**0.150**	0.0211	**0.1726**
-2	- 0.041	0.092	**- 0.084**	**0.095**	**- 0.1104**	**0.2425**
-1	**0.109**	**0.186**	**0.512**	**0.367**	- 0.0370	**0.2417**
0	**0.796**	**0.605**	**0.532**	**0.411**	**0.5763**	**0.4092**
1	**0.169**	**0.167**	- 0.014	**0.218**	**0.5704**	**0.4597**
2	0.010	**0.120**	- 0.062	**0.112**	**- 0.1221**	**0.1287**
3	0.015	**0.079**	0.032	**0.160**	**- 0.1484**	**0.1275**

MEXADR are listed Mexican ADRs, OTCADR are over-the-counter ADRs, MEXUDR and OTCUDR are underlying stocks of the MEXADR and OTCADR, respectively. MEXNDX is the Mexican peso index and SPNDX is the S&P 500 index. All series are from January 1993 to December 1996, except for the OTCADR and OTCUDR which report data for 20 December 1994 to December 1996. Standard errors are in brackets. The coefficients and p-values that are significant at the 5% level are in **bold**. LB(x) is the Ljung-Box Q statistic for the test of autocorrelation up to lag x.

IV. Main Results

IV. A. Host versus Home Market: The Relative Influences on Mexican ADRs

Table 6.3 reports the results from a model with two lags in the conditional mean and a GARCH(1,1) conditional variance for the S&P 500, Mexican index, and the ADRs. Panel A presents the coefficients of the mean equations and their associated robust t values, while Panel B reports the coefficients and t values of the conditional variances. The remainder of the table displays standardized residual diagnostics and robust Wald tests of parameter restrictions. Table 6.4 displays the standardized impulse response coefficients and forecast error variance decomposition of a three-lag VAR system. Unstandardized impulse response graphs are in Figure 6.2.

In the mean equations there is support for the previous finding by other researchers that price changes in the US market spill over to foreign markets, but there is usually no reciprocal transmission to the US. The US market leads the Mexican market by one day on average and there is a tendency for these markets to move in the same direction; i.e., the first lag of the S&P 500 is significant in the equation of the Mexican index (coefficient = 0.108, t = 2.05). However, the ADRs are not influenced by the two lags of the US returns. This could be indicating either that the ADRs are not influenced by the US market or that they incorporate relevant information contemporaneously with the US. There is strong lagged interdependence between the Mexican market and its ADRs.

Table 6.3 GARCH(1,1) Estimates of Spillovers: S&P 500, Mexican (Peso) Index, and ADRs

January 4, 1993 to December 31, 1996

Panel A **Mean Spillovers**

	Lag	US Returns Coeff.	US Returns t-value	Mexican Returns Coeff.	Mexican Returns t-value	ADRs Return Coeff.	ADRs Return t-value
US Returns	1	0.072	3.095	0.108	2.051	0.110	1.262
	2	-0.005	-0.239	-0.050	-0.946	-0.022	-0.293
Mexican Returns	1	-0.002	-0.162	0.165	6.888	0.213	4.609
	2	0.003	0.221	-0.052	-2.326	-0.054	-1.404
ADRs Returns	1	0.009	1.461	0.055	3.156	-0.008	-0.248
	2	0.002	0.255	0.023	1.394	-0.004	-0.140
Constant		0.006	0.367	0.173	4.382	0.112	1.897
Monday Dummy		0.065	1.819	-0.191	-2.724	-0.112	-1.180
Holiday Dummy		-0.114	-1.787	-0.166	-1.745	-0.191	-1.428
Crash Dummy	.	0.087	4.072	-0.067	-1.166	-0.101	-1.077

Panel B **Variance Spillovers**

Lagged Conditional Variance

	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
US Volatility	0.962	56.84	0.041	0.658	0.040	0.502
Mexican Volatility	-0.024	-2.076	0.765	15.24	-0.172	-2.688
ADRs Volatility	0.001	0.311	-0.016	-0.425	0.935	18.63

Lagged Squared Errors

US Shock	0.162	4.189	-0.234	-2.745	-0.268	-1.823
Mexican Shock	0.016	1.211	0.232	3.971	-0.144	-1.648
ADRs Shock	0.013	1.545	0.224	3.697	0.523	5.849

Panel C **Standardized Residual Diagnostics**

	US Index		Mexican Index		ADRs Index	
Skewness (p-value)	-0.314	0.000	0.104	0.187	0.144	0.069
Kurtosis (p-value)	1.664	0.000	0.862	0.000	1.615	0.000
Jarque-Bera (p-value)	126.6	0.000	31.50	0.000	107.6	0.000
Autocorrelation (Level)						
LB (6) (p-value)	10.25	0.115	3.270	0.774	0.475	0.998
LB (12) (p-value)	17.10	0.146	9.127	0.692	6.031	0.915
Autocorrelation (Squared)						
LB (6) (p-value)	7.364	0.288	2.229	0.897	3.852	0.697
LB (12) (p-value)	11.53	0.484	4.496	0.973	5.304	0.947
LM (ARCH in Residuals)	3.232	0.520	1.252	0.869	3.299	0.509
Loglikelihood	-1088.574					

Robust Wald Tests of Parameter Restrictions

(1) Zero restrictions on block of lags in conditional mean equations

$$\chi^2 (18) = 277.542, \; p\text{-value} = 0.000$$

(2) Zero restrictions on coefficients (including dummies) in conditional variance (and covariance) equations

$$\chi^2 (36) = 344502, \; p\text{-value} = 0.000$$

(3) Zero restrictions on dummy coefficients in conditional mean equations

$$\chi^2 (9) = 35.186, \; p\text{-value} = 0.000$$

All t -values are based on a quasi-maximum likelihood estimation robust to non-normality in the residuals. All residual diagnostics are based on standardized residuals. LB(x) is the Ljung-Box chi-squared statistics with associated p-values for testing the null hypothesis of zero autocorrelation up to the xth lag. LM is the Lagrange multiplier test - χ^2 and p-value - for ARCH in the residuals, with 4 degrees of freedom.

This is reflected in the significant first lag of the ADRs in the Mexican equation (coefficient = 0.055, t = 3.16) and the first lag of the Mexican index in the ADRs equation (coefficient 0.213, t = 4.61).

This intra-market dependence suggests that the markets do not concurrently impound relevant information, which could be a result of information asymmetry, differences in transaction costs between Mexico and the US, and other reasons. The ADRs are not forecast by their own mean, consistent with the lack of significant autocorrelation in the ADRs index.

In Panel B of Table 6.3 there is an economically small but statistically significant spillover of past variance from the Mexican index to the US (coefficient = -0.024, t = -2.08), but no reciprocal lagged variance spillover to Mexico. However, past shocks to the US market impact on the current volatility of the Mexican index (coefficient = -0.234, t = -2.75) and are of the same magnitude but opposite sign as the shocks from either the Mexican index itself (coefficient = 0.232, t = 3.97) or from the ADRs (coefficient = 0.224, t = 3.7). The ADRs react significantly to the lagged variance of the Mexican index (coefficient = -0.172, t = -2.69) and marginally to the past shocks of both the US (coefficient = -0.268, t = -1.82) and Mexican indices (coefficient = -0.144, t = -1.65).

Innovation Accounting. To further understand the dynamic patterns of interaction between these three markets, Table 6.4 (Panel B) reports (only) the 1-step ahead to 5-step ahead *forecast error variance decomposition* from the three-variable, three-lag

VAR system. The relation to the previous results is that the percentage influence of market X in the decomposed forecast error variance of market Y reflects the extent to which X transmits price changes to Y.

In the first block, the S&P 500 explains 100% of its 1-step-ahead forecast error variance and experiences little change even up to the 12-step-ahead forecast, suggesting that the S&P 500 should be removed from the system of equations. However, this is in contradiction to likelihood ratio tests for block exogeneity and block causality of the S&P 500 (not reported) but consistent with the GARCH results that the US is not influenced by the Mexican markets. Similarly, the Mexican peso index explains over 93% of its own error variance over a twelve-day horizon, with the remaining 7% explained by the US market.

About 55% of the error variance of the ADRs is explained by the Mexican index and about 10% by the US, suggesting that the Mexican market is relatively more influential than the US. The ADRs explain just over a third of their own forecast error variance.

Table 6.4 Impulse Responses and Forecast Errors: S&P 500, Mexican Index, and ADRs

January 4, 1993 to December 31, 1996

Panel A

Responses to Shock in SPNDX

Day	SPNDX	MEXNDX	MEXADR
0	1.000	0.256	0.318
1	0.081	0.142	0.096
2	0.011	0.055	0.041
3	- 0.108	- 0.154	- 0.251
4	- 0.017	- 0.053	- 0.039
5	- 0.003	- 0.010	0.001

Responses to Shock in MEXNDX

Day	SPNDX	MEXNDX	MEXADR
0	0.000	0.967	0.741
1	0.002	0.166	0.233
2	0.006	- 0.008	- 0.098
3	0.006	0.018	0.003
4	0.003	0.013	0.008
5	- 0.002	0.000	0.008

Responses to Shock in MEXADR

Day	SPNDX	MEXNDX	MEXADR
0	0.000	0.000	0.592
1	0.000	0.020	- 0.059
2	- 0.002	0.010	0.045
3	0.009	0.016	- 0.031
4	- 0.001	0.000	0.015
5	0.001	0.001	- 0.005

Panel B

Decomposition of Variance for Series SPNDX

Step	SPNDX	MEXNDX	MEXADR
1	100.0	0.00	0.00
2	99.99	0.01	0.00
3	99.98	0.02	0.00
4	99.82	0.08	0.10
5	99.82	0.09	0.09
6	99.82	0.09	0.09

Decomposition of Variance for Series MEXNDX

Step	SPNDX	MEXNDX	MEXAD R
1	6.57	93.43	0.00
2	7.19	92.71	0.10
3	7.26	92.62	0.12
4	7.57	92.25	0.18
5	7.61	92.21	0.18
6	7.61	92.21	0.18

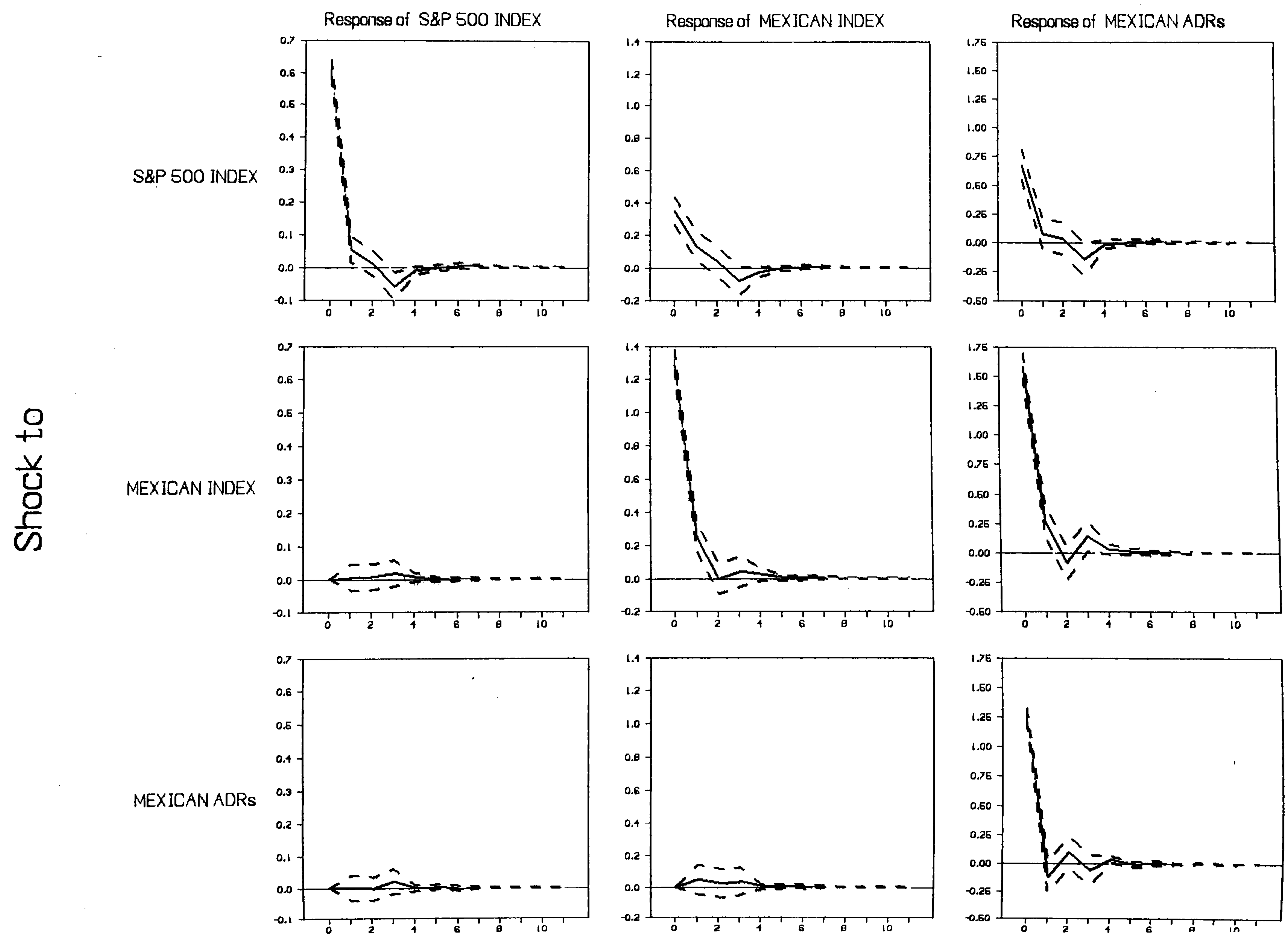
Decomposition of Variance for Series MEXADR

Step	SPNDX	MEXNDX	MEXADR
1	10.08	54.92	35.00
2	10.00	55.33	34.67
3	9.98	55.29	34.73
4	10.35	55.16	34.49
5	10.35	55.15	34.50
6	10.35	55.15	34.50

SPNDX is the S&P 500 index, MEXNDX is the Mexican (Peso) index, and MEXADR is a portfolio of Mexican ADRs. All coefficients of the impulse responses are based on residuals standardized by dividing by their respective standard deviations. See Figure 6.2 for plots of unstandardized impulse responses from a three-lag model.

Fig. (6.2) Impulse Responses: S&P 500, MEXICAN INDEX & MEXICAN ADRs

See table for standardized coefficients



Impulse Responses. The impulse responses (graphed in Figure 6.2) capture the dynamic reaction of one market to a random positive shock in the innovations of another. The impulse coefficients reported in Panel A of Table 6.4 can be viewed as the moving-average coefficients (divided by their standard errors) in the vector-moving average representation of the VAR system. A one-standard-deviation shock to the S&P 500 leads to an increase of 0.256 standard deviations above the mean for the Mexican index and 0.318 standard deviation increase for the ADRs in the same period (day 0). On day 1 the US market is only about 0.08 above its mean, but the Mexican index increased by 0.14 and the ADRs by 0.096 units. On day 3 the direction of the impact is reversed in all three markets with a decline of 0.108, 0.154, and 0.25 units by the S&P 500, the ADRs, and the Mexican index, respectively. Thereafter, the impact declines rapidly to zero. This result suggests that the Mexican assets responded with a lag to the S&P 500, however, from the impulse response graphs it is clear that the impulses are all within the two-standard-error bands.

A one-standard-deviation shock to the Mexican index results in an increase of 0.74 units by the portfolio of ADRs in the current period. In the subsequent period (day 1) the peso index causes a 0.23 unit response in the ADRs and 0.12 on day 3. These are all more than twice the size of the responses to the shock from the S&P 500. There is hardly any influence from the ADRs on either of the markets. It is evident that there are lagged responses in the ADRs market to the shocks from the Mexican market, but given the insignificant impulses it is hardly likely that one could make abnormal profits from trading in the ADRs informed by the past price changes in the Mexican market.

Model diagnostics reported in Panel C of Table 6.3 suggest that the GARCH model is well specified. Both Ljung-Box[55] chi-square and Lagrange Multiplier tests indicate that the model removes the raw and squared autocorrelation of the series. The model failed to remove the skewness in two of the series and the excess kurtosis from any of the series. A robust Wald test resoundingly rejects the null hypotheses of no interdependence in the means and of constant variances, respectively.

We can conclude, therefore, that from the unconditional cross-correlations, the significant mean and volatility interdependence of the GARCH specification, the composition of the forecast error variances, and the magnitude and persistence (if not significance) of the impulse responses of the VAR model, the Mexican ADRs act more like national than like US securities. If Mexico is the most integrated of the Latin American markets (e.g., Bekaert and Harvey (1994), Levine and Zervos (1996)), then it would not be unreasonable to conclude that virtually all Latin American ADRs act more like national assets rather than like US securities[56].

IV. B. Transmissions Between the Mexican Markets: A Further Assessment

In this section I pursue three tests. First, I repeat the above test without the US in the system of equations. Next, I test the relation between the ADRs and their underlying

[55] De Santis and Imrohoroglu (1996), end note 12, state that recent work has shown that this test is more powerful in detecting misspecification than the LM test of Engle (1982), but Susmel and Engle (1994) state that they are inappropriate in the presence of heteroscedasticity and non-normal errors and only suitable for preliminary checks. The Ljung-Box test is known to have low power in small samples and may indicate significance not only in the presence of serial correlation but also when the model is misspecified, e.g., having omitted variables or wrong functional form.
[56] Note, however, that this is not a direct test of integration, hence, any inferences about integration can only be tentative. The issue of integration is directly investigated in another chapter.

stocks. Finally, I attempt to reduce the impact of the peso/dollar exchange rate by first regressing the ADRs and their underlying stocks on two lags of the log first difference of the peso/dollar exchange rate and then use the residuals to conduct the test. The intensity of mean and volatility spillover between the Mexican assets, in the absence of the direct influence of the S&P 500, might increase since the ADRs' transmission to the local market may now include a proxy for the US factor. However, if the ADRs are segmented from the US market, then this need not be the case.

To check for robustness of the results I form a portfolio of 12 over-the-counter ADRs (OTCADRs) in the post-crash period and include their results in the remaining tests. As an indication of their frequency of trading during the sample period, the underlying stocks of 10 of the OTCADRs were listed among the 35 stocks in the main Mexican index, the IPC, which is used by the Chicago Mercantile Exchange for futures trading. Furthermore, I select only those stocks with the highest market values at the end of the sample period since larger stocks are more likely to trade more frequently and have lower serial correlation (e.g., Cohen et al. (1986)). Also, the end-of-period market value is used as the basis for selection since, given the negative price repercussion of the peso crash, if a selected number of stocks are currently 'large' there is every chance that they have been so for most of the period under review.

Interdependence Between the Mexican Index and the ADRs. The results in Table 6.5 are mixed with respect to the bi-directional transmissions observed previously. In the conditional mean, there are significant spillovers between the listed ADRs and the Mexican index. The one-day lag return on the ADRs positively predicts the mean of the local market (coefficient = 0.062, t = 2.74), and the first lag of the Mexican index predicts the mean of the ADRs (coefficient = 0.224, t = 3.58). The mean of the over-the-counter ADRs (OTCADRs), on the other hand, is strongly dependent on the first lag of the Mexican market (coefficient = 1.08, t = 21.6) but does not itself influence the mean of the Mexican index. In the conditional variance, the Mexican index is dependent on the past squared errors of the listed ADRs (coefficient = 0.168, t = 2.83) but the volatility of the listed ADRs is not dependent on the past volatility of the local market. However, there is interdependence in the volatility between the OTCADRs and the local index. The past variance of the OTCADRs has a significant impact on the index (coefficient = -0.053, t = -2.99) while the past squared errors of the index impact the volatility of the OTCADRs (coefficient = 0.462, t = 4.8).

Tables 6.6A and 6.6B show the error decomposition and standardized impulse response coefficients. The Mexican index accounts for nearly 100% of its own error variance, elicits large current and lagged responses from both sets of ADRs, and does not respond to shocks from the ADRs. The index also contributes about two thirds of the error variance of the listed ADRs but only about 45% of the error variance of the OTCADRs. The (unstandardized) impulse graphs from a three-lag model are in Figures 6.3 and 6.3b.

Table 6.5 GARCH(1,1) Estimates of Spillovers Between the Mexican (Peso) Index and ADRs

Panel A — Mean Spillovers

		January 4, 1993 to December 31, 1996				December 20, 1994 to December 31, 1996			
		Mexican Returns		Listed ADRs Returns		Mexican Returns		OTCADRs Returns	
	Lag	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value
Mexican Returns	1	0.174	5.222	0.224	3.584	0.319	7.839	1.080	21.61
	2	-0.041	-1.175	-0.064	-0.951	-0.077	-1.461	-0.022	-0.253
	3					-0.026	-0.706	-0.043	-0.849
ADRs Return	1	0.062	2.737	-0.003	-0.073	-0.035	-1.086	-0.309	-8.248
	2	0.011	0.386	0.003	0.057	-0.009	-0.356	-0.105	-1.864
	3					0.022	1.022	-0.032	-0.871
Constant		0.161	5.835	0.101	2.186	0.152	3.111	0.126	1.863
Monday Dummy		-0.261	-3.483	-0.164	-1.377	-0.278	-2.080	-0.245	-1.617
Holiday Dummy		-0.176	-1.793	-0.233	-1.713	-0.255	-1.956	-0.469	-2.389
Crash Dummy		-0.032	-0.685	-0.069	-0.934				

Panel B — Variance Spillovers

Lagged Conditional Variance

	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value
Mexican Volatility	0.869	5.381	-0.075	-0.412	-0.883	-30.89	0.031	0.709
ADRs Volatility	-0.051	-0.864	0.885	9.349	-0.053	-2.992	-0.900	-33.71

Lagged Squared Errors

	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value
Mexican shock	0.222	1.743	-0.162	-0.894	0.247	5.024	0.462	4.798
ADRs shock	0.168	2.829	0.518	3.958	0.010	0.261	-0.529	-7.278

Panel C — Standardized Residual Diagnostics

	Mexican Index		ADRs Index		Mexican Index		ADRs	
Skewness (*p*-value)	0.125	0.113	0.141	0.074	0.326	0.003	-0.330	0.003
Kurtosis (*p*-value)	0.947	0.000	1.814	0.000	0.608	0.007	3.246	0.000
Jarque-Bera (*p*-value)	38.40	0.000	134.8	0.000	16.02	0.003	219.6	0.000
Autocorrelation (Level)								
LB (6) (*p*-value)	2.516	0.867	0.490	0.998	2.433	0.876	8.252	0.220
LB (12) (*p*-value)	7.986	0.786	6.108	0.911	5.990	0.917	13.18	0.356
Autocorrelation (Squared)								
LB (6) (*p*-value)	2.111	0.909	4.185	0.652	4.369	0.627	2.595	0.858
LB (12) (*p*-value)	5.537	0.938	5.863	0.923	11.20	0.512	47.29	0.000
LM (ARCH in Residuals)	1.801	0.772	3.517	0.475	3.902	0.419	4.080	0.396
Loglikelihood	-1184.840				-779.805			

Robust Wald Tests of Parameter Restrictions

(1) Zero restrictions on block of lags in conditional mean equations

χ^2 (8) = 183.646, *p*-value = 0.000 $\quad$ χ^2 (12) = 6 60.585, *p*-value = 0.000

(2) Zero restrictions on coefficients (including dummies) in conditional variance (and covariance) equations

χ^2 (17) = 366042, *p*-value = 0.000 $\quad$ χ^2 (14) = 39150.871, *p*-value = 0.000

(3) Zero restrictions on dummy coefficients in conditional mean equations

χ^2 (6) = 28.233, *p*-value = 0.000 $\quad$ χ^2 (4) = 12.560, *p*-value = 0.014

All *t* -values are based on a quasi-maximum likelihood estimation robust to non-normality in the residuals. All residual diagnostics are based on standardized residuals. LB(x) is the Ljung-Box chi-squared statistics with associated *p*-values for testing the null hypothesis of zero autocorrelation up to the xth lag. LM is the Lagrange multiplier test - χ^2 and p-value - for ARCH in the residuals, with 4 degrees of freedom.

Table 6.6A Impulse Responses and Forecast Errors of the Mexican Index and ADRs

January 4, 1993 to December 31, 1996

Panel A

Responses to Shock in MEXNDX

Day	MEXNDX	MEXADR
0	1.000	0.799
1	0.180	0.240
2	- 0.008	- 0.101
3	0.005	0.101
4	0.007	0.002
5	0.002	0.012

Responses to Shock in MEXADR

Day	MEXNDX	MEXADR
0	0.000	0.602
1	0.026	- 0.057
2	0.015	0.050
3	0.009	- 0.045
4	- 0.001	0.015
5	- 0.000	- 0.007

Panel B

Decomposition of Variance for MEXNDX

Step	MEXNDX	MEXADR
1	100.0	0.00
2	99.84	0.16
3	99.79	0.21
4	99.77	0.23
5	99.77	0.23
6	99.77	0.23

Decomposition of Variance for MEXADR

Step	MEXNDX	MEXADR
1	63.78	36.22
2	64.14	35.86
3	64.04	35.96
4	63.97	36.03
5	63.96	36.04
6	63.96	36.04

Table 6.6B Impulse Responses and Forecast Errors: Mexican Index and OTCADRs

December 20, 1993 to December 31, 1996

Responses to Shock in MEXNDX

Day	MEXNDX	OTCADR
0	1.000	0.509
1	0.249	1.376
2	0.023	- 0.045
3	- 0.026	- 0.233
4	0.026	- 0.104
5	0.018	0.099

Decomposition of Variance for MEXNDX

Step	MEXNDX	OTCADR
1	100.0	0.00
2	98.69	1.31
3	98.38	1.62
4	98.25	1.75
5	98.21	1.79
6	98.21	1.79

Responses to Shock in OTCADR

Day	MEXNDX	OTCADR
0	0.000	0.861
1	- 0.059	- 0.140
2	- 0.029	- 0.200
3	0.019	- 0.051
4	0.011	0.081
5	- 0.002	0.026

Decomposition of Variance for OTCADR

Step	MEXNDX	OTCADR
1	25.94	74.06
2	47.03	52.97
3	46.00	54.00
4	46.54	53.46
5	46.37	53.63
6	46.46	53.54

MEXNDX is the Mexican index, MEXADR is a portfolio of listed Mexican ADRs, and OTCADR are over-the-counter ADRs. Coefficients of the impulse responses are standardized by dividing by their respective standard deviations. See Figures 6.3 and 6.3b for plots of unstandardized impulse responses for a three-variable model.

Fig. (6.3) Impulse Responses: MEXICAN INDEX & MEXICAN ADRs

See table for standardized coefficients

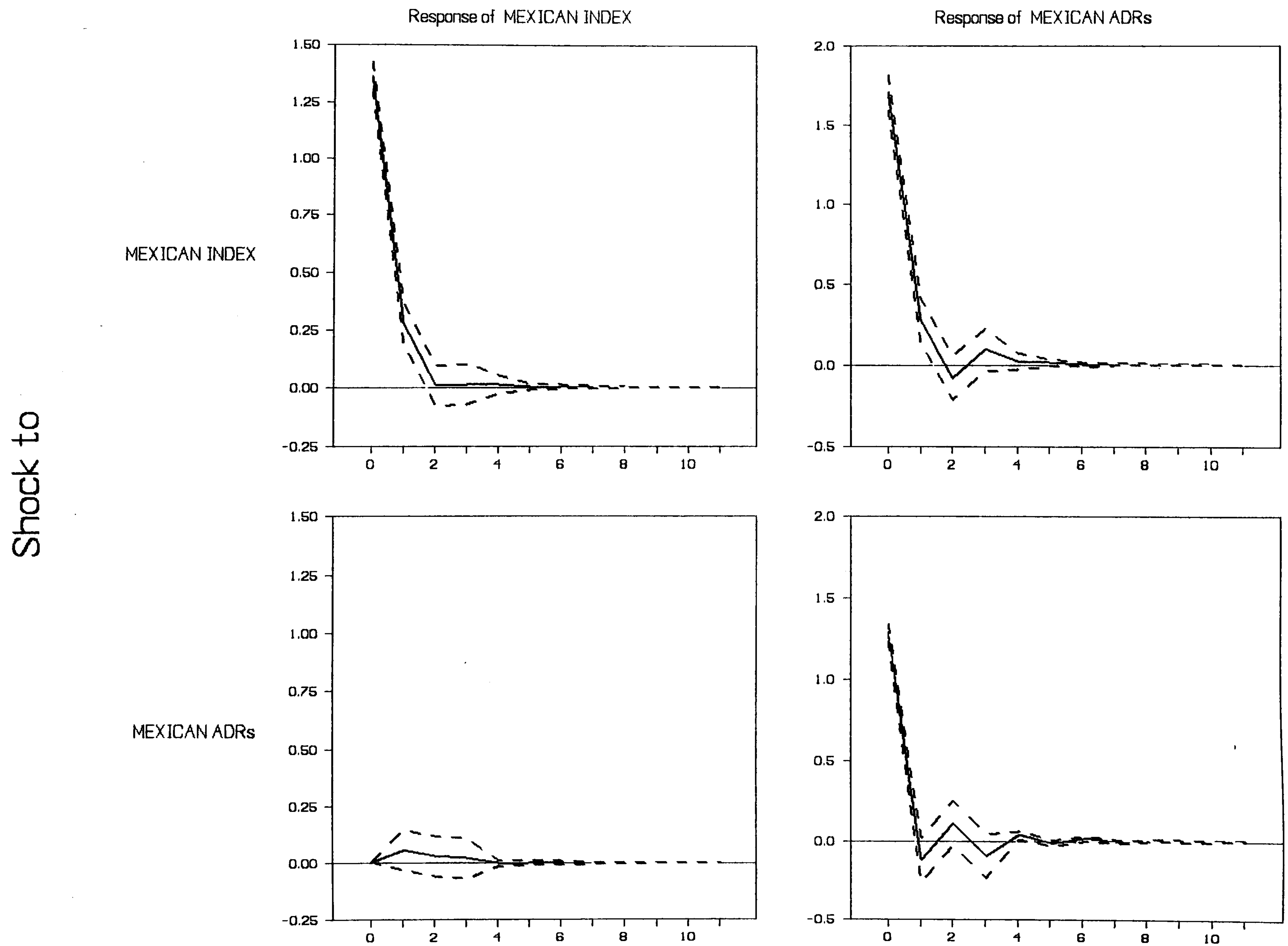
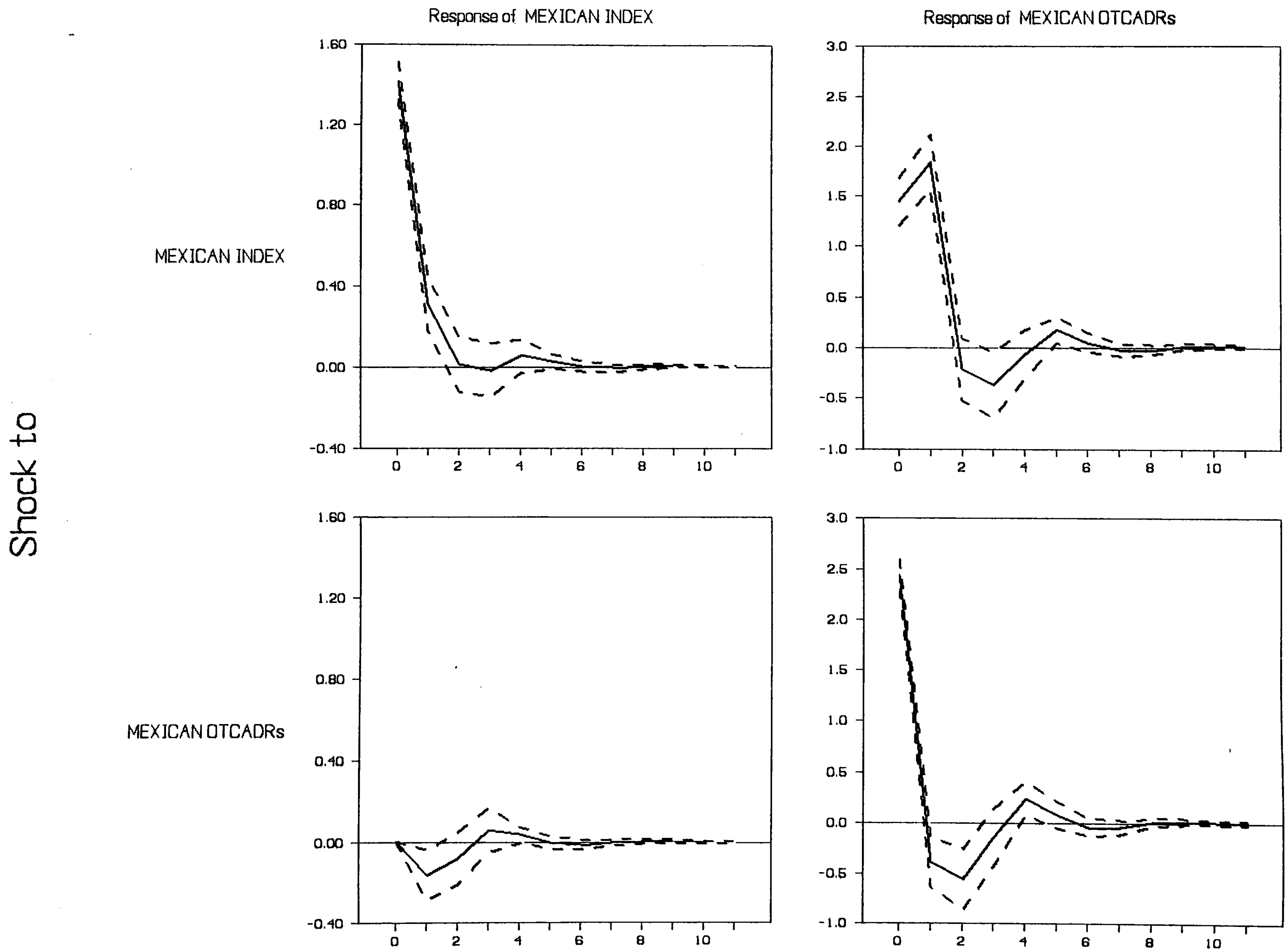


Fig. (6.3b) Impulse Responses: MEXICAN INDEX & MEXICAN OTCADRs

See table for standardized coefficients



Interdependence Between the ADRs and their Underlying Stocks. Table 6.7 provides consistent and significant evidence of reverse mean and volatility spillovers. In the conditional mean, the listed ADRs are predicted by the first lag of their underlying stocks (coefficient = 0.309, t = 7.18) while the OTCADRs depend on the first (second) lag of their underlying stocks (coefficients = 0.935 (0.234), t = 17.51 (4.79)). On the other hand, the means of the portfolios of underlying stocks are predicted by the first lag of the listed ADRs (OTCADRs) with coefficient = 0.129 and t = 2.04 (coefficient = -0.114, t = -2.08).

In the conditional variance equations the volatility of the listed ADRs is forecast by both the lagged volatility and squared errors of their underlying stocks (coefficient = -1.465 and -0.519, t = -7.82 and -2.93, respectively). The conditional variance of the OTCADRs is predicted only by the past squared errors of their underlying stocks (coefficient = 0.296, t = 4.86). To complete the cycle of volatility feedback, the volatility of the underlying stocks is predicted by the first lag of the volatility and squared error terms of the listed ADRs (coefficient = -0.102 and -0.299, t = - 1.9 and -1.72, respectively), while the volatility of the underlying stocks of the OTCADRs depends only on the past volatility of the OTCADRs (coefficient = -0.220, t = -2.22).

The VAR results in Tables 6.8A and B and Figure 6.4 plots the unstandardized impulse responses. Apart from the underlying stocks of the listed ADRs, each asset accounts for at least a third of the forecast error of the other and each asset displays between 0.175 and 0.81 unit response to a one-unit shock in the other.

Table 6.7 GARCH(1,1) Estimates of Spillovers Between ADRs and Their Underlying Stocks

Panel A — **Mean Spillovers**

		January 4, 1993 to December 31, 1996				December 20, 1994 to December 31, 1996			
		Listed ADRs		Underlying Returns		OTCADRs Returns		Underlying Returns	
	Lag	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
ADRs Return	1	-0.163	-3.919	0.129	2.038	-0.507	-9.924	-0.114	-2.077
	2	-0.088	-1.838	0.003	0.057	-0.246	-5.234	-0.045	-1.146
	3					-0.149	-2.687	0.024	0.463
	4					-0.046	-0.982	-0.008	-0.186
Underlying	1	0.309	7.178	0.002	0.035	0.935	17.51	0.320	6.083
	2	0.068	1.412	-0.023	-0.471	0.234	4.793	0.010	0.164
	3					0.092	1.447	-0.050	-0.914
	4					0.053	1.073	-0.021	-0.315
Constant		0.120	2.216	0.172	3.513	0.152	2.193	0.227	2.773
Monday Dummy		-0.157	-1.221	-0.279	-2.552	-0.283	-2.058	-0.385	-2.460
Holiday Dummy		-0.282	-1.639	-0.146	-0.989	-0.542	-2.875	-0.415	-1.803
Crash Dummy		-0.094	-0.947	-0.069	-0.855				

Panel B — **Variance Spillovers**

Lagged Conditional Variance

	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
ADRs Volatility	0.819	13.41	-0.102	-1.895	-0.947	-16.365	-0.220	-2.220
Underlying Volatility	-1.465	-7.817	-0.435	-2.250	0.024	0.269	-0.703	-4.322

Lagged Squared Errors

	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
ADRs shock	0.074	0.367	-0.299	-1.718	-0.433	-5.286	0.198	1.617
Underlying shock	-0.519	-2.933	-0.165	-1.074	0.296	4.859	0.215	3.830

Panel C — **Standardized Residual Diagnostics**

	Listed ADRs		Underlying		OTCADRs		Underlying	
Skewness (p-value)	0.074	0.351	0.037	0.641	-0.143	0.198	0.211	0.059
Kurtosis (p-value)	1.520	0.000	1.181	0.000	2.255	0.000	0.902	0.000
Jarque-Bera (p-value)	93.34	0.000	56.04	0.000	103.4	0.000	19.87	0.000
Autocorrelation (Level)								
LB (6) (p-value)	4.547	0.603	1.045	0.984	9.875	0.130	3.420	0.755
LB (12) (p-value)	10.81	0.546	5.667	0.932	10.84	0.543	4.470	0.973
Autocorrelation (Squared)								
LB (6) (p-value)	1.113	0.981	6.600	0.359	14.48	0.025	4.948	0.551
LB (12) (p-value)	3.144	0.994	10.491	0.573	19.20	0.084	14.24	0.286
LM (ARCH in Residuals)	0.393	0.983	4.565	0.335	13.64	0.009	3.491	0.479
Loglikelihood	-1263.0				-928.185			

Robust Wald Tests of Parameter Restrictions

(1) Zero restrictions on block of lags in conditional mean equations

χ^2 (8) = 198.168, p-value = 0.000 $\qquad$ χ^2 (16) = 965.089, p-value = 0.000

(2) Zero restrictions on coefficients (including dummies) in conditional variance (and covariance) equations

χ^2 (17) = 271093, p-value = 0.000 $\qquad$ χ^2 (14) = 41814, p-value = 0.000

(3) Zero restrictions on dummy coefficients in conditional mean equations

χ^2 (6) = 9.142, p-value = 0.003 $\qquad$ χ^2 (4) = 16.226, p-value = 0.003

All t -values are based on a quasi-maximum likelihood estimation robust to non-normality in the residuals. All residual diagnostics are based on standardized residuals. LB(x) is the Ljung-Box chi-squared statistics with associated p-values for testing the null hypothesis of zero autocorrelation up to the xth lag. LM is the Lagrange multiplier test - χ^2 and p-value - for ARCH in the residuals, with 4 degrees of freedom.

Table 6.8A Impulse Responses and Forecast Errors for the ADRs and Their Underlying

January 4, 1993 to December 31, 1996

Panel A

Responses to Shock in MEXADR

Day	MEXADR	MEXUDR
0	1.000	0.752
1	0.110	0.085
2	- 0.023	- 0.001
3	0.017	- 0.008
4	- 0.003	- 0.001
5	0.002	- 0.000

Responses to Shock in MEXUDR

Day	MEXADR	MEXUDR
0	0.000	0.660
1	0.175	0.048
2	- 0.099	- 0.007
3	0.030	- 0.035
4	- 0.017	0.001
5	0.009	- 0.002

Panel B

Decomposition of Variance for MEXADR

Step	MEXADR	MEXUDR
1	100.0	0.00
2	98.15	1.85
3	97.57	2.43
4	97.52	2.48
5	97.50	2.50
6	97.50	2.50

Decomposition of Variance for MEXUDR

Step	MEXADR	MEXUDR
1	56.48	43.52
2	56.73	43.27
3	56.73	43.27
4	56.66	43.34
5	56.66	43.34
6	56.66	43.34

Table 6.8B. Impulse Responses and Forecast Errors for OTCADRs and Their Underlying

December 20, 1993 to December 31, 1996

Panel A

Responses to Shock in OTCADR

Day	OTCADR	OTCUDR
0	1.000	0.630
1	0.318	0.007
2	- 0.206	- 0.071
3	- 0.130	- 0.002
4	0.053	0.036
5	0.056	0.008

Responses to Shock in OTCUDR

Day	OTCADR	OTCUDR
0	0.000	0.776
1	0.807	0.158
2	- 0.012	0.006
3	- 0.133	- 0.069
4	- 0.072	0.022
5	0.064	0.019

Panel B

Decomposition of Variance for OTCADR

Step	OTCADR	OTCUDR
1	100.0	0.00
2	65.82	34.18
3	66.68	33.32
4	66.37	33.63
5	66.27	33.73
6	66.18	33.82

Decomposition of Variance for OTCUDR

Step	OTCADR	OTCUDR
1	39.74	60.26
2	38.78	61.22
3	39.12	60.88
4	38.94	61.06
5	39.01	60.99
6	39.00	61.00

MEXADR is a portfolio of Mexican ADRs, MEXUDR is the portfolio of their underlying stocks, OTCADR is a portfolio of over-the-counter ADRs, and OTCUDR is their underlying stocks. All coefficients of the impulse responses are based on residuals standardized by dividing by their respective standard deviations. See Figures 6.4 and 6.4b for plots of unstandardized impulse responses from a three-variable model.

Impact of Exchange Rate Changes. Table 6.9 displays the results from the returns made orthogonal to the changes in the peso/dollar rate by regressing the asset returns on two lags of the exchange rate changes and using the residuals as the new regressands. The results are comparable to those in Table 6.7. In the mean equations there is no significant difference between the two sets of results.

Fig. (6.4) Impulse Responses: MEXICAN ADRs & UNDERLYING STOCKS

See table for standardized coefficients

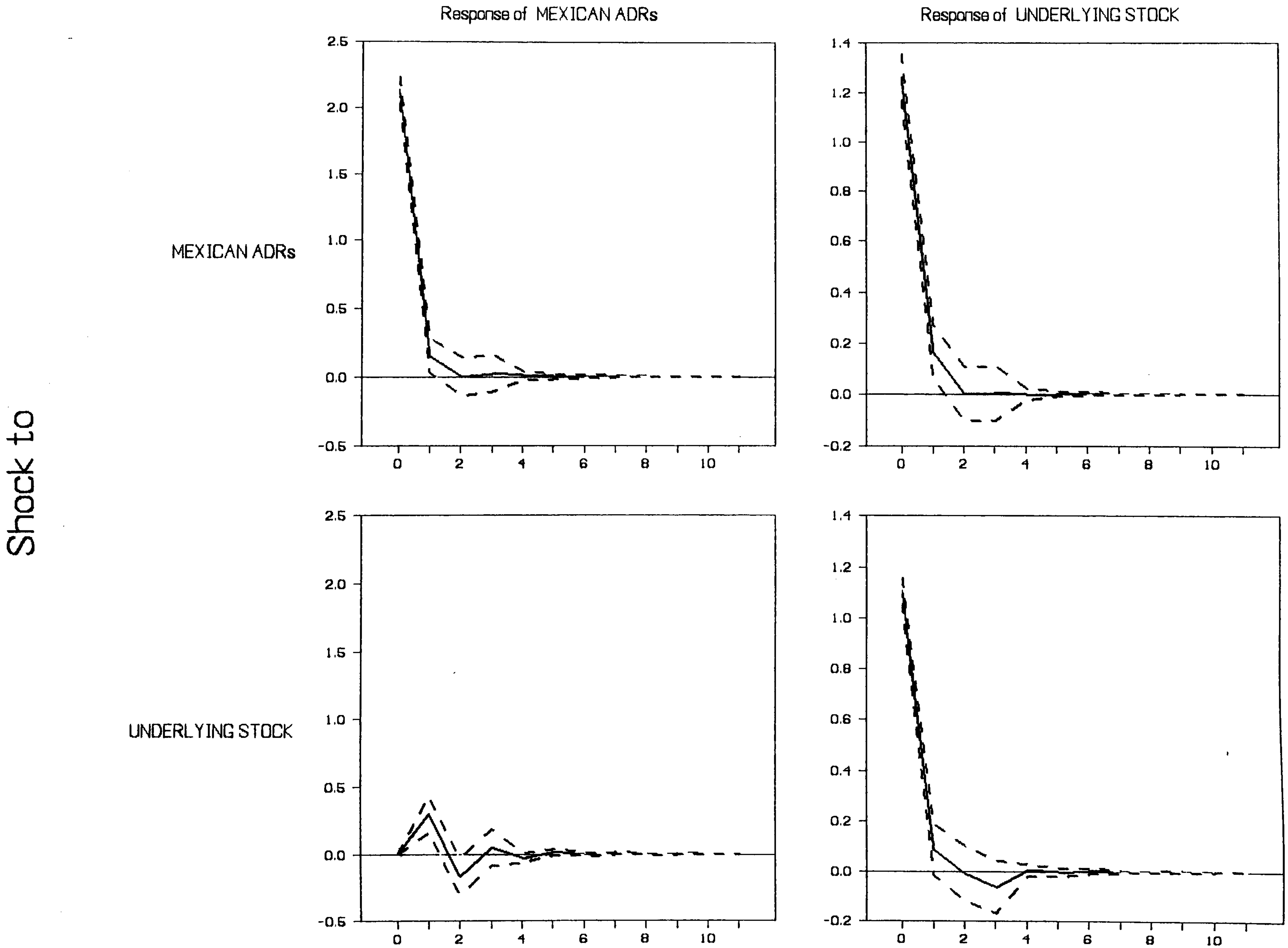
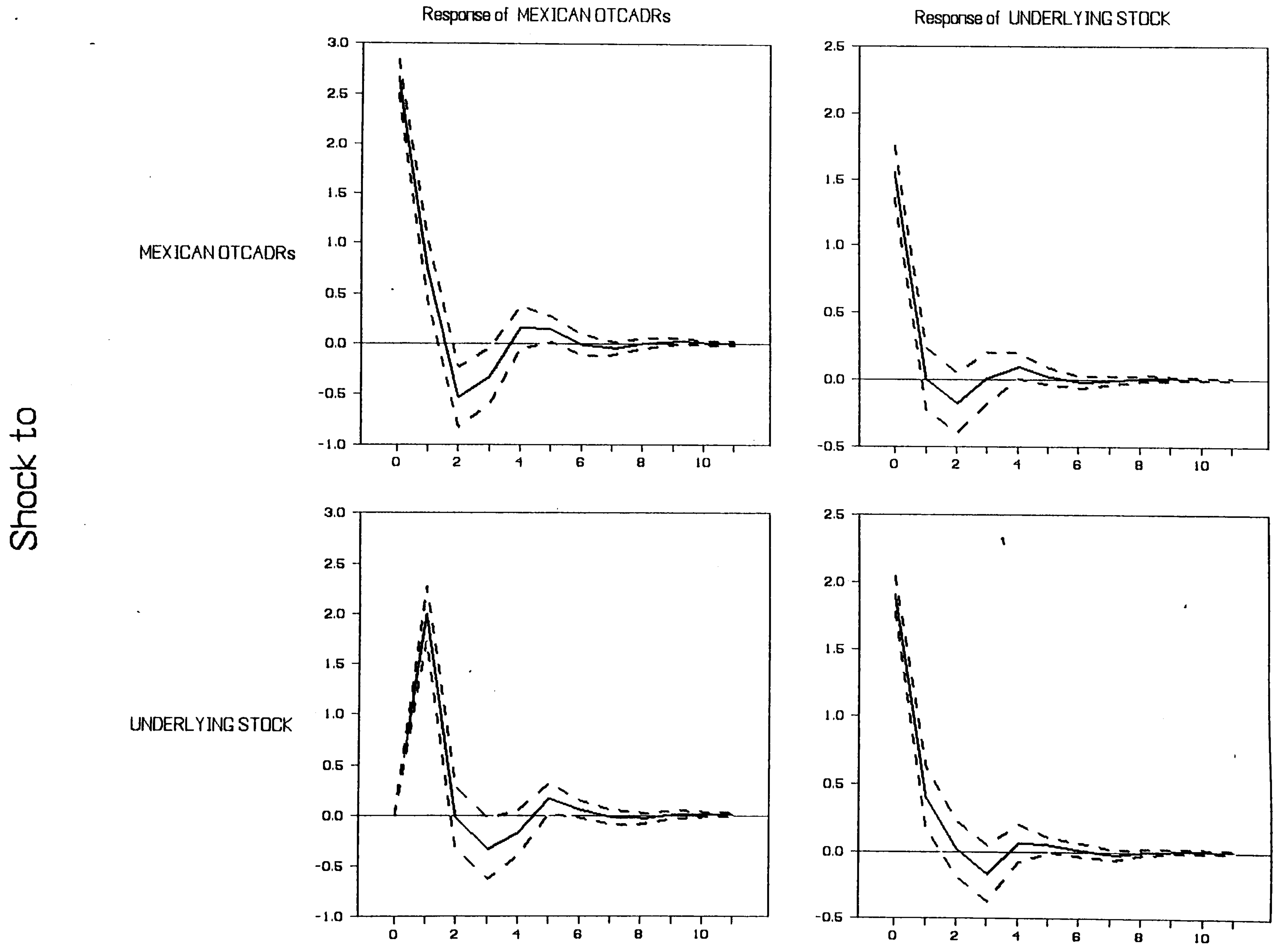


Fig. (6.4b) Impulse Responses: MEXICAN OTCADRs & UNDERLYING STOCKS

See table for standardized coefficients



However, the OTCADRs now have less autocorrelation, due possibly to the removal of exchange rate-induced autocorrelation. On the other hand, while there is no significant change in the absolute values of the coefficients in the conditional variance, there is a change of sign in all but one coefficient. Previously, in Table 6.7, an increase in the volatility of the underlying stocks led to a decline in the volatility of the ADRs on the following day. In Table 6.9, where the currency impact is considered, this relationship is positive, (but only for the listed ADRs), as is expected.

In this section I have investigated lagged mean and volatility spillovers between the Mexican index and the Mexican listed and over-the-counter ADRs, between the Mexican ADRs and their underlying stocks, and then accounted for the impact of exchange rate changes on the dynamics between the ADRs and their underlying stocks. There are significant spillovers between the Mexican markets, even though there is some sensitivity to the exclusion of the US market. The reverse spillovers for both the listed and over-the-counter ADRs are significant. The negative response of the ADRs to lagged changes in the volatility of their underlying stocks (and vice versa) is quite likely due to the volatility of the peso/dollar exchange rate. This is supported by the reversal of this perverse relationship once the exchange rate changes are accounted for in the equity returns. Furthermore, the reverse spillovers are not due to an imbalance in trading volume between the ADRs and their underlying stocks even though 75% of all trades in Mexican cross-listed stocks take place in New York (Domowitz et al. (1997).) To be consistent with a volume effect, the spillovers would have to be uni-directional, from the ADRs to the slower-traded underlying stocks. The bi-directional spillovers negate any such interpretation of the results.

Table 6. 9 Spillovers Between the ADRs and Their Underlying - Returns Orthogonal to Exchange Rate Changes

		January 4, 1993 to December 31, 1996				December 20, 1994 to December 31, 1996			
Panel A		**Mean Spillovers**							
		Listed ADRs		Underlying Stocks		OTCADRs Returns		Underlying Stocks	
	Lag	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value
ADRs Returns	1	-0.142	-2.420	0.176	2.793	-0.571	-12.81	-0.285	-3.711
	2	-0.094	-1.608	0.022	0.456	-0.223	-4.700	-0.082	-1.745
Underlying Returns	1	0.287	4.679	-0.045	-0.712	0.943	31.71	0.374	7.990
	2	0.070	1.098	-0.043	-0.854	0.324	4.782	0.146	2.051
Constant		0.284	4.178	0.159	2.455	0.167	2.230	0.078	1.024
Monday Dummy		-0.173	-1.342	-0.294	-2.745	-0.446	-3.030	-0.608	-3.740
Holiday Dummy		-0.293	-1.170	-0.161	-0.702	-0.304	-1.300	-0.231	-0.870
Crash Dummy	.	-0.249	-2.479	-0.127	-1.522				

Panel B **Variance Spillovers**

Lagged Conditional Variance

	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value
ADRs Volatility	-0.825	-9.267	0.096	1.223	0.906	13.61	0.407	3.054
Underlying Volatility	1.448	7.043	0.417	2.008	-0.103	-0.749	-0.236	-2.262

Lagged Squared Errors

	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value
ADRs Error	-0.069	-0.587	0.302	2.958	0.721	7.688	1.021	9.045
Underlying Error	0.516	4.793	0.162	1.787	- 0.296	-4.444	-0.167	-1.423

Panel C **Standardized Residual Diagnostics**

	ADRs		Underlying		OTCADRs		Underlying	
Skewness (*p*-value)	0.088	0.264	0.037	0.638	0.004	0.970	0.326	0.004
Kurtosis (*p*-value)	1.574	0.000	1.212	0.000	1.599	0.000	1.079	0.000
Jarque-Bera (*p*-value)	100.3	0.000	58.96	0.000	51.16	0.000	31.77	0.000
Autocorrelation (Level)								
LB (6) (*p*-value)	3.900	0.690	0.819	0.992	11.96	0.063	6.701	0.349
LB (12) (*p*-value)	10.01	0.615	4.741	0.966	15.14	0.234	8.761	0.723
Autocorrelation (Squared)								
LB (6) (*p*-value)	1.007	0.985	7.107	0.311	1.320	0.971	1.993	0.920
LB (12) (*p*-value)	2.943	0.996	11.65	0.474	17.05	0.148	9.810	0.633
LM (ARCH in Residuals)	0.358	0.986	5.091	0.278	1.647	0.800	0.122	0.998
Loglikelihood	-1252.835				-957.444			

Robust Wald Tests of Parameter Restrictions

(1) Zero restrictions on block of lags in conditional mean equations

χ^2 (8) = 112.798, *p*-value = 0.000 χ^2 (12) = 1472.441, *p*-value = 0.000

(2) Zero restrictions on coefficients (including dummies) in conditional variance (and covariance) equations

χ^2 (17) = 979946.24, *p*-value = 0.000 χ^2 (14) = 17761.155, *p*-value = 0.000

(3) Zero restrictions on dummy coefficients in conditional mean equations

χ^2 (6) = 21.218, *p*-value = 0.002 χ^2 (4) = 16.917, *p*-value = 0.002

All *t* -values are based on a quasi-maximum likelihood estimation robust to non-normality in the residuals. All residual diagnostics are based on standardized residuals. LB(x) is the Ljung-Box chi-squared statistics with associated *p*-values for testing the null hypothesis of zero autocorrelation up to the xth lag. LM is the Lagrange multiplier test - χ^2 and p-value - for ARCH in the residuals, with 4 degrees of freedom.

IV. C. Is There Regional Contagion?

The final issue considered is the relation between the region's ADRs. The results for the full period and the post-crash period are in Table 6.10. In the conditional mean equations there is no evidence of inter-market feedback, but the returns on the non-Mexican ADRs are predicted by the first lag and by the first two lags of the Mexican ADRs in the full and post-crash periods, respectively. This predictive power of Mexico could be indicating that Mexico is the pace setter in the region with news tending to be impounded first by its stocks and then by the stocks of the other markets. In the conditional variance equations the lagged shocks to the non-Mexican ADRs predict the volatility of the Mexican ADRs in the full period. There is no other significant spillovers.

There is no support for a regional contagion effect. The fact that Bailey et al. (1998) find some spillover in variance between the Mexican and non-Mexican markets may be due to their use of intra-day data focused on a short period around the crash. In fact, a plot of the conditional variances reported in Table 6.10 does indicate common volatility for only a very short time around the crash. That this paper does not find significant spillovers reflects the fact that apart from a few days after the crash there is no common volatility between these markets (see Susmel (1997b) for corroboration).

Table 6.10 Spillovers Between Mexican ADRs and Non-Mexican (Latin American) ADRs

Panel A — **Mean Spillovers**

		January 4, 1993 to December 31, 1996				December 20, 1994 to December 31, 1996			
		Mexican ADRs		Non-Mexican ADRs		Mexican ADRs		Non-Mexican ADRs	
	Lag	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value
Mexican Returns	1	0.076	3.776	0.084	5.432	0.070	1.707	0.129	5.850
	2	-0.024	-0.637	0.030	1.176	-0.003	-0.065	0.065	2.888
Non-Mexican Returns	1	0.101	1.188	0.106	2.377	0.060	1.285	0.026	0.722
	2	0.046	0.519	-0.055	-1.140	0.098	1.375	-0.076	-1.825
Constant		0.095	1.330	0.056	1.245	0.112	1.402	0.067	1.494
Monday Dummy		-0.205	-1.152	-0.024	-0.219	-0.164	-0.844	-0.069	-0.732
Holiday Dummy		0.110	0.286	-0.158	-0.979	0.232	0.803	-0.214	-1.353
Crash Dummy		-0.032	-0.434	0.004	0.077				

Panel B — **Variance Spillovers**

Lagged Conditional Variance

	Mexican ADRs		Non-Mexican ADRs		Mexican ADRs		Non-Mexican ADRs	
	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value
Mexican Volatility	0.983	23.12	0.091	0.752	0.746	8.604	0.024	0.274
Non-Mexican Volatility	-0.283	-1.055	0.809	5.432	0.146	1.435	0.903	7.736

Lagged Squared Errors

	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value
Mexican shock	0.341	8.740	0.003	0.030	0.525	3.192	-0.034	-0.323
Non-Mexican shock	0.230	3.175	0.315	3.172	0.071	0.862	0.258	2.831

Panel C — **Standardized Residual Diagnostics**

	Mexican ADRs		Non-Mexican ADRs		Mexican ADRs		Non-Mexican ADRs	
Skewness (*p*-value)	0.205	0.009	0.019	0.811	0.019	0.864	0.053	0.627
Kurtosis (*p*-value)	1.571	0.000	0.794	0.000	1.845	0.000	0.680	0.002
Jarque-Bera (*p*-value)	108.1	0.000	25.87	0.000	68.12	0.000	9.476	0.009
Autocorrelation (Level)								
LB (6) (*p*-value)	0.990	0.986	5.969	0.427	3.063	0.801	5.682	0.460
LB (12) (*p*-value)	8.885	0.713	12.29	0.423	9.390	0.669	12.45	0.410
Autocorrelation (Squared)								
LB (6) (*p*-value)	8.454	0.207	8.773	0.187	3.033	0.805	3.946	0.684
LB (12) (*p*-value)	9.778	0.635	12.70	0.391	6.814	0.870	8.685	0.730
LM (ARCH in Residuals)	7.044	0.134	7.462	0.113	2.522	0.641	2.701	0.609
Loglikelihood	-1605.461				-763.97			

Robust Wald Tests of Parameter Restrictions

(1) Zero restrictions on block of lags in conditional mean equations

χ^2 (8) = 191.005, *p*-value = 0.000 χ^2 (8) = 59.290, *p*-value = 0.000

(2) Zero restrictions on coefficients (including dummies) in conditional variance (and covariance) equations

χ^2 (17) = 223823, *p*-value = 0.000 χ^2 (14) = 43028, *p*-value = 0.000

(3) Zero restrictions on dummy coefficients in conditional mean equations

χ^2 (6) = 5.342, *p*-value = 0.501 χ^2 (4) = 3.486, *p*-value = 0.480

All *t*-values are based on a quasi-maximum likelihood estimation robust to non-normality in the residuals. All residual diagnostics are based on standardized residuals. LB(x) is the Ljung-Box chi-squared statistics with associated *p*-values for testing the null hypothesis of zero autocorrelation up to the xth lag. LM is the Lagrange multiplier test - χ^2 and p-value - for ARCH in the residuals, with 4 degrees of freedom.

V. Summary and Conclusions

This paper employs multivariate GARCH and VAR models to investigate the relative influence of the US (international) and Mexican (national) markets on predicting the mean and volatility of Mexican ADRs listed on the main US exchanges. It further examines the relations between both listed and over-the-counter ADRs and their underlying stocks, and between the Mexican and non-Mexican ADRs. This study includes features that help to understand the pricing of emerging markets' assets, which has implications for market integration, trading strategy and portfolio diversification, and securities regulation. The time period of the study, January 1993 to December 1996, follows major institutional changes resulting in market liberalization in Mexico and spans the period over which the market experienced a significant shock due to the Mexican peso crash of December 1994. Other researchers have found that the probability of observing return and volatility transmission between markets is increased during periods of high volatility when the price changes in one market are large enough to induce trade in the other, given the inertia caused by transaction costs.

Main findings.

1. From the analysis of cross-correlations, the significant mean and volatility feedback between the ADRs and the Mexican index, the composition of the forecast error variances, and the magnitude and persistence (if not significance) of the impulse responses of the VAR model, the evidence strongly suggests that the

ADRs act more like Mexican securities and are exposed more to local market factors than to US (international) factors.

2. There are strong reverse spillovers between the depositary receipts and their underlying stocks. There is also significant inter-market feedback between the Mexican national market and both its listed and over-the-counter ADRs.
3. Given the significant reverse spillovers, it seems that the Mexican market is not fully integrated into the international capital markets. The lagged spillovers are unlikely to be caused by autocorrelation in the indices or to be induced by foreign exchange volatility, even though it appears that the volatility of the currency market does affect the dynamics between the ADRs and their underlying stocks. Furthermore, the bi-directional reverse spillovers cannot be accounted for by the asymmetry in the volume of trade in Mexican securities between New York and Mexico City.
4. There is no significant volatility spillover between the Latin American markets.

Some Implications. The lagged spillovers may be indicating that although the Mexican market has been substantially liberalized, there could exist vestiges of barriers to international investment that result in the lagged response of the market to relevant international information. This may be so especially in the banking sector where there remain restrictions on foreign investors. However, since many government-imposed impediments and other barriers have been lifted, it could well be that part of the segmentation results from (US) investor attitudes and irrationality (e.g., Gultekin, Gultekin, and Penati (1989)). The lagged response may also be reflecting the relatively higher cost of trading in the Mexican market due to greater bid-ask spreads and other transaction costs. This might explain in part why, for instance, over 75% of all transactions in Mexican cross-listed stocks take place in New York.

If there is information asymmetry between Mexican and US investors in the ADRs market (see Urias (1996)), then this could result in the ADR prices impounding Mexican information at a slower rate than their underlying stocks, hence, partly explaining the spillover from the underlying to the ADRs. This is a matter that can be addressed partly by legislative and structural reforms by the Mexican authorities. The dependence of the underlying stocks on the lagged prices of the ADRs may be caused from slower trading in the underlying stocks, which in turn may result from the higher cost of trading in the local market, among other causes.

The lagged responses of the ADRs raise the question of whether or not abnormal profits can be earned on the basis of information gained from past price movements in the US market or whether there may be profitable arbitrage between the underlying assets and the ADRs. The efficient market hypothesis (e.g., Fama (1965, 1970, 1991)) would rule out the possibility of both over any extended period. Furthermore, given the dependence of derivative prices on the volatility of the underlying assets, the lagged response of the conditional volatility of the ADRs to Mexican and US price changes may be an important feature in devising trading and hedging strategies employing Mexican derivatives. Additionally, the response of the equities market to peso/dollar volatility suggests that the implied volatility of Mexican currency options may have incremental predictability for the volatility of the ADRs.

Mexico is one of the largest emerging markets, recently liberalized with updated and (foreign) investor-friendly trading systems and regulations, and economically integrated with the US. The fact that it still exhibits signs of financial segmentation indicates how daunting is the prospect of international asset pricing in emerging markets. New definitions of "liberalization" may have to be considered which encompass not only the period over which an emerging market implements changes to its trading and legal systems but also the point at which foreign investors consider the market liberalized enough to enter[57]. It may be that the Mexican market reforms of 1989 and 1992 have not been fully reflected in the attitudes of foreign investors in the period over which this study is based.

57 This argument is based on a suggestion by Professor Campbell Harvey that liberalization can also be defined as the point at which there is a substantial change in the inflows of capital to an emerging market. This may not coincide with liberalization defined otherwise.

Chapter 7. Latin American ADRs, Country Funds, and Diversification: Implications of the Peso Crash

In increasingly integrated international capital markets the avenues for portfolio diversification lead inevitably into the emerging markets. Several recent papers find that over long periods there have been gains from diversifying into these markets[58]. For instance, De Santis (1994) finds that the Latin American assets in his sample of emerging and developed markets provided the greatest benefit to the US investor. One important question not previously considered, however, concerns how diversification is affected by cataclysmic events such as currency crashes and political and economic instability. While investors are aware of the higher probability of such events occurring in the emerging markets and adjust their expectations accordingly, their timing and intensity are difficult to forecast. The most vivid examples of these catastrophes are the Taiwan market crash of 1992, the Mexican peso crash of December 1994, and the Asian currency crisis of 1997.

Furthermore, as research in developed markets show, these events sometimes have quite unexpected consequences. For instance, Blume, MacKinlay, and Terker (1989) find that the October 1987 stock market crash caused very different price changes for constituents of the S&P 500 index compared with non-constituents. Harris (1989) finds that in the period immediately surrounding the crash the linkage between the S&P 500 index and the corresponding index futures disintegrated, leading to a substantial basis which cannot be explained by nonsynchroneity in the cash index.

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[58] See Divecha, Drak, and Stefek (1992), De Santis (1994), Errunza (1994), Harvey (1994a, b, 1995), Bekaert and Urias (1995), Chang, Eun, and Kolodny (1995), and Susmel (1997a).

Finally, Bailey and Ng (1991) find that during the silver crash of 1979 to 1980 the prices of silver futures incorporated a large time-varying nonperformance premium.

This paper adds to the international finance literature by exploring the impact of the Mexican peso crash of December 1994 on the international portfolio diversification provided by Latin American ADRs and country funds to US investors. The returns on developed markets generally do not span the emerging markets, which are characterized by higher average returns and volatility, low but time-varying correlation with the returns on the developed markets, and are more predictable using both local and global instruments (e.g., Bekaert and Harvey (1995), Harvey (1994a)). The large fluctuations in risk and return and the changing correlation with the developed markets impact on the gains from diversification and are a deterrent to foreign investors.

There are several other motivations for this study. First, the issue of whether or not there are differences in the diversification offered by Latin American ADRs and country funds is addressed. Evidence in Bailey, Chan, and Chung (1998) suggests that US institutions may be the main investors in Latin American ADRs while country funds are held primarily by individual investors. These clienteles might have different risk aversions and expectations and thus may price these derivative assets differently.

Second, the issue of whether or not the gains from investing in the Mexican assets were affected differently from the gains from investing in non-Mexican securities is also examined. Financial analysts and researchers suggest that there is a "Tequila

Effect" in Latin America which drives the region's stock markets as though they are one market[59]. Susmel (1997b) finds that a Latin-American factor is priced by the region's market and that the Mexican index proxies well for this factor in tests of the international CAPM in the markets of Argentina, Brazil, and Chile.

Third, I investigate the effect of the crash on the diversification provided by the Asian markets as there have been suggestions that they too were affected by the fallout of the Latin American crisis. The 1997 currency crash in Asia has had a debilitating effect on the equities markets of the Asian region. The lessons learned from the Latin American crisis may be instructive in dealing with the crisis in Asia, or other emerging markets.

I find that the Latin American ADRs (except Mexican ADRs) and country funds provided significant diversification before the crash to the US investor holding domestic assets. There was no diversification after the crash. This paper examines various explanations including a test of a signaling hypothesis versus an hypothesis that the ADRs experienced poor post-listing performance. The remainder of the paper contains four sections. Section I describes the data while Section II presents the

[59] As Mexico has become one of the leading hosts for foreign portfolio investments in the emerging markets, particularly for debt instruments, it is felt that the peso crisis had a spillover effect in Latin America. During the height of the crisis (December 19 to 28, 1994), the Argentine and Brazilian stock markets fell by 14% and 17% in dollar value, respectively; their Brady bond markets experienced a downturn and an increase of 389 and 207 basis points in the spreads on these bonds; Argentina sold $353 million of reserves, more than in any time in the three previous years; Argentine interbank interest rates increased from 9.5% to 23% in response to a decline in deposits of $313 million in the banking system and the collapse of a wholesale bank. Over the next several months, both markets experienced other severe problems forcing their respective governments to make substantial policy adjustments. In 1994, Venezuela was faced with serious political and economic problems which resulted in a banking crisis starting with the collapse of Banco Latino in January and which contributed to the imposition of currency controls in July. Both Chile and Colombia experienced small devaluation and equity market declines in the first quarter of 1995. Several Asian markets had mixed experiences which may or may not have been caused by the crash (IMF (1995)).

methodology. The results are in Section III and the summary and conclusions are in section IV.

I. Data

The data for this study include the daily return on the Standard and Poor's (S&P 500) Composite Index (denoted SPNDX), daily returns on portfolios of Latin American (LATDR), developed markets (EuroDR), and non-Latin American (rest of the emerging markets, EMADR) ADRs, and daily returns on country funds of emerging markets. These are obtained from the Center for Research in Securities Prices (CRSP) database. The daily return on the daily Fed funds rate is used as a proxy for the US risk-free rate. This is obtained from the Chicago Federal Reserve Board. Two series of daily exchange rates, the Mexican peso/dollar and the dollar/pound exchange rates are obtained from Datastream International. All returns are 100 times the log-price differences and cover the period January 1992 to December 1996.

Test Assets. The primary test assets are constructed from over 60 ADRs and four country funds from Argentina, Chile, and Mexico that are listed on the main exchanges of the US. The Mexican ADRs (MEXADR) account for about half the total number of ADRs. A portfolio of ADRs mainly from Asian emerging markets and a country fund from Thailand make up the rest of the test assets from the emerging markets. A large portfolio of ADRs from France, Japan, and the UK (EuroDR) is also used to add validity to the tests.

Spanning Assets. The spanning portfolios are:

1. The S&P 500 index
2. The S&P 500 index and the risk-free (proxy) asset.
3. The S&P 500 and the European ADRs.

Information variables. The information vector contains a constant, lagged return on the Mexican (peso) index, lagged return on the S&P 500 index, and lagged changes on the peso/dollar and the dollar/pound exchange rates.

II. Methodology

II. A. Introduction to Mean-Variance Spanning

The primary technique employed in this study is mean-variance spanning, which is motivated by the mathematics of the mean-variance frontier (e.g., Roll (1977)). The technique is a multivariate test of asset pricing and can be used to evaluate the performance of a portfolio. For instance, it can be used to assess the diversification gained by acquiring assets such as small capitalization stocks when one is already invested in larger stocks, or by adding international assets to a domestic portfolio. Other uses of mean-variance spanning include evaluating the performance of a portfolio manager and estimating the impact of foreign currency hedging on internationally diversified portfolios.

The roots of its derivation is in Shanken (1986) and Huberman and Kandel (1987). Bekaert and Urias (1995) formulate a version of the test using the pricing kernel in the fundamental asset-pricing model and the relation between mean-variance frontiers and the Hansen-Jagannathan (H-J, 1991) bounds. Bekaert and Urias build on a methodology developed in De Santis (1995, 1994); Harvey (1994a) and Jobson and Korkie (1989) adopt the CAPM framework; Lehman and Modest (1988) note that different exact factor pricing models (of the APT) depend on whether or not the entire mean-variance frontier of a set of securities is well diversified[60] (which implies mean-variance spanning) or whether only one portfolio on the frontier is well diversified (implying mean variance intersection); Ferson, Foerster, and Keim (1993) demonstrate that the latent variable asset pricing model can be restricted to be consistent with the null hypothesis of mean-variance spanning, while Ferson (1995) and De Santis (1997) review mean-variance spanning.

The test of a portfolio's efficiency falls into the general framework of deducing whether or not we can construct an efficient portfolio from a subset of a larger set of assets. In other words, whether a portfolio from K assets is efficient with respect to a larger set of N assets or whether the efficient frontier spanned by the K assets coincides with the frontier formed from the N assets. The principle of *K-fund separation* (see Constantinides and Malliaris (1995) for a review) states that the entire minimum-variance frontier traced out by the portfolios from a *set* of assets can be replicated by the appropriate combination of a *subset* of K distinct portfolios on the frontier. If we take a set of assets and trace out an efficient frontier, then a subset of those assets (called the spanning assets or the factor-mimicking assets) will form a boundary which lies either on the inside (to the right) of the first boundary, intersects

[60] A well-diversified portfolio is one in which, as the number of assets contained therein goes to infinity the diversifiable (idiosyncratic) risk goes to zero. The three exact factor pricing models of the APT relate to the type of risk contained in the portfolios that can be formed from a large (infinite) set of risky assets, when each asset is priced by a linear factor model. Such portfolios can contain no factor or idiosyncratic risk, both types of risks, or only factor risk.

at one point only with the first boundary, or intersects at two or more points. If the latter occurs, then the two boundaries have to coincide and this is termed *mean-variance spanning*. In the case where the boundaries touch once, *mean-variance intersection* is said to exist.

If mean-variance spanning exists, then the full set of assets[61] must be well-diversified, containing only factor/systematic risks and, hence, having a well-diversified efficient frontier. As a result, we can form as many as K portfolios (from the subset of assets), equivalent to the number of common factors underlying the return-generating process of the set of assets, which will be sufficient to span the mean-variance frontier of the larger set of assets. This gives rise to exact factor pricing in the APT framework. The resulting restrictions are exploited to test for mean-variance spanning. When the limiting minimum variance portfolio is not well-diversified, the K spanning portfolios will not span the mean-variance frontier.

II. B. The Huberman-Kandel (1987) Model

Let $\mathbf{R}$ be an $N \times 1$ vector of asset returns and trace out a mean-standard deviation frontier from these assets. Define $\mathbf{R}_1$ as the $K \times 1$ vector of returns on the spanning (factor-mimicking) assets and $\mathbf{R}_2$ as the $(N\text{-}K) \times 1$ vector of returns on the remaining N-K (test) assets. If the mean-standard deviation frontier of the subset of K assets were to span that of the set of N assets, then we conclude that the diversification

[61] Lehman and Modest (1988) refer to this larger set as the "limiting minimum variance portfolio" assuming it is "infinitely large".

(reward/risk ratio) provided by the additional N-K assets is not significantly different from zero; i.e., we test the null hypothesis that $\mathbf{R}_1$ spans $\mathbf{R}$.

Consider the following linear model:

$$\mathbf{R}_{2,t} = \mathbf{a} + \mathbf{B}\mathbf{R}_{1,t} + \mathbf{e}_{2,t} \tag{7.1}$$

where $\mathbf{a}$ and $\mathbf{e}_{2,t}$ are N-K vectors, and $\mathbf{B}$ is an $(N\text{-}K)\times K$ matrix of coefficients. Imposing orthogonality $\mathrm{E}(\mathbf{e}_{2,t}) = \mathbf{0}$, where $\mathbf{0}$ is the null vector, Huberman and Kandel (1987) show that mean-variance spanning exists when the following linear restrictions hold:

H_0: The minimum-variance frontier of the subset $\mathbf{R}_1$ *spans* the frontier of set $\mathbf{R}$:

$$\mathbf{a} = \mathbf{0} \text{ and } \mathbf{B}\iota_K = \iota_{N\text{-}K} \text{ or } \sum_{j=1}^{K} bij = 1, \quad i = K+1,\ldots, N, \tag{7.2}$$

where ι_K is the K-dimension unit vector. For each asset in the set of test assets $\mathbf{R}_2$, if the intercept is zero and the regression coefficients sum to one, then the unconditional mean-variance boundary of the larger set $\mathbf{R}$ of N assets can be generated from the returns of the subset, $\mathbf{R}_1$, and unconditional mean-variance spanning is said to exist. Intuitively, if we extend a line from the average return on the zero-beta (risk-free) rate in mean-standard deviation space tangential to the frontier of the subset of assets $\mathbf{R}_1$, then its slope is equal to the slope of a similar line tangential to the frontier of the full set of assets $\mathbf{R}$.

Rejection of mean-variance spanning may result from a breach of normality and homoscedasticity assumptions. Therefore, I estimate the model using the Generalized Method of Moments (GMM, Hansen (1982)). Additionally, it is well-known that the CAPM, from which mean-variance spanning evolves, is a conditional asset-pricing model (e.g., Jagannathan and Wang (1996), Ferson (1995)). With increasing evidence of time-varying expected returns (e.g., Ferson and Korajczyk (1995)) and time-varying integration of the emerging markets (e.g., Bekaert and Harvey (1994)), the unconditional model may not be sufficiently informative and may understate the gains from diversification. In other words, the unconditional model may under-reject the null hypothesis, thus, suggesting the existence of spanning when diversification has actually been achieved. Moreover, conditioning the model on information available to the investor assumes that an actively-managed portfolio strategy is being employed. The GMM easily incorporates conditioning information.

II. C. Estimation using GMM

Let the orthogonality condition be:

$$E(\mathbf{e}_{2,t} \otimes \mathbf{R}_{1,t}) = E\left[(\mathbf{R}_{2,t} - \mathbf{B}\mathbf{R}_{1,t}) \otimes \mathbf{R}_{1,t}\right] = \mathbf{0}, \tag{7.3}$$

subject to the constraint that $\sum_{j=1}^{K} b_{ij} = 1$, and $i = K+1,\ldots,N$, where $\otimes$ is the Kronecker product. Under the null hypothesis of mean-variance spanning, the system is over identified as there are $(N\text{-}K)\times K$ orthogonality conditions and only $(N\text{-}K)\times(K\text{-}1)$ unknown parameters, leaving $N\text{-}K$ degrees of freedom. The GMM is used to estimate the matrix of coefficients **B**. As the true expectation is unobservable, consider the sample moments for equation (7.3):

$$\mathbf{h}_T(b_{ij}) = \frac{1}{T}\sum_{t=1}^{T}\left[(\mathbf{R}_{2,t} - b_{ij}\mathbf{R}_{1,t}) \otimes \mathbf{R}_{1,t})\right]. \tag{7.4}$$

But, since there are generally more elements in $\mathbf{h}_T$ than there are parameters, not all the orthogonality conditions will be equal to zero. We, therefore, form the quadratic:

$$\mathbf{G}_T(b_{ij}) = \mathbf{h}'_T(b_{ij})\mathbf{W}_T\mathbf{h}_T(b_{ij}), \tag{7.5}$$

where the vector $\mathbf{h}_T$ is cross-multiplied to produce a matrix of squares and cross-products. These are then scaled by an optimal weighting matrix, $\mathbf{W}_T$, which is symmetric and positive definite. GMM chooses consistent estimators of b_{ij} from:

$$\min_{b_{ij}} \mathbf{h}'_T(b_{ij})\mathbf{W}_T\mathbf{h}_T(b_{ij}). \tag{7.6}$$

The weighting matrix is the inverse of the covariance matrix of the orthogonality conditions averaged over the T observations. When this weighting matrix is used, T

times the minimized objective function has a χ^2 distribution with degrees of freedom given by the excess of the orthogonality conditions over the estimated parameters. The J test of over-identifying restrictions, consistent with mean-variance spanning, is:

$$J_T = T[\mathbf{h}'_T(b_{ij})\mathbf{W}_T\mathbf{h}_T(b_{ij})] \sim \chi^2_{N-K}. \tag{7.7}$$

II. D. Conditional Mean-variance Spanning

The unconditional model assumes a passive investor engaged in a buy-and-hold portfolio strategy whereby her initial wealth allocation to the various assets remains in force over the investment horizon. The assumption of an actively-managed portfolio strategy, within the context of highly volatile emerging markets, is more plausible. Hence, I condition on information from the investor's information set. Furthermore, unconditional spanning tends to bias the test statistic against rejecting the null hypothesis. The GMM test is generalized to include conditioning information. If the asset returns are conditioned on a set of information that is available to the investor at the time of making a decision and if such conditioning information is highly correlated with the changes in investors' expectations, then the conditional mean-variance spanning test is as follows. Consider $\mathbf{Z}_{t-1}$ as an L vector of information variables which is a subset of the full information set. Let the orthogonality conditions be $E(\mathbf{e}_{2,t} \otimes \mathbf{R}_{1,t} | \mathbf{Z}_{t-1}) = \mathbf{0}$. By the law of iterated expectation (and including $\mathbf{R}_{0,t}$, the risk-free asset, as the first asset in the vector of spanning assets), we obtain:

$$E\left[\left(\mathbf{R}_{2,t}-\mathbf{B}\begin{bmatrix}\mathbf{R}_{0,t}\\ \mathbf{R}_{1,t}\end{bmatrix}\right)\otimes\begin{bmatrix}\mathbf{R}_{0,t}\\ \mathbf{R}_{1,t}\end{bmatrix}\otimes\mathbf{Z}_{t-1}\right]=\mathbf{0} \tag{7.8}$$

and $\sum_{j=1}^{K} b_{ij} = 1,\ \ i = K+1,\ldots,N$, with ($N$-$K$)×$K$×$L$ orthogonality conditions.

Iterated GMM is used in the estimation as it has better finite-sample properties and is invariant to the scaling of the data and to the initial weighting matrix. The p-values are based on the Newey-West heteroscedasticity- and autocorrelation-consistent covariance matrix, with a lag-truncation parameter a function of the number of observations. Since the GMM does not converge if the number of orthogonality conditions gets too large, portfolios rather than individual assets are used in the tests.

III. Empirical Results

III. A. Preliminary Data Analysis

Among all emerging markets, the Latin American markets list the largest number of depositary receipts in the US. There are also several single- and multiple-market closed-end country funds. Tables 7.1 to 7.3 present primary statistics on both sets of instruments for the region. I also include a portfolio of ADRs from several Asian emerging markets and the Thai country fund as well as a portfolio of ADRs selected from three developed markets, France, Japan, and the UK. As a backdrop, Figure 6.1 (see previous chapter) provides a comparative plot of the Mexican peso and dollar indices, the S&P 500, and the ADRs index against the peso/dollar exchange rate over the period 1993 to 1996. Both Mexican indices and the ADRs index suffered a major downturn in the last quarter of 1994 exemplified, e.g., by a 26% drop in the dollar index on December 22, 1994. These markets reached their nadir in first quarter 1995. Subsequently, the Mexican market has been experiencing a steady increase in (peso) share prices. The dollar index reflects the volatility of the foreign exchange market as it fell from an average of about 500 points in the pre-crash period to a noticeably lower average of about 400 in the post-December 1994 period. It is worth recalling that the steep descent in the index was precipitated by the over 15% devaluation of the peso against the dollar on December 20, 1994, followed by another approximately 21% devaluation on December 22, 1994.

Table 7.1 indicates that only the S&P 500 index registered an average return significantly different from zero in the period under review. The Latin American ADRs on average had a daily return of -0.014% in the full period while the Mexican ADRs performed even more negatively. The Mexican ADRs were the most volatile of ADRs in all periods with an average daily standard deviation of 2.09% in the full period and 2.50% in the period following the peso crash. Overall, the Mexico Fund is the most volatile asset for the region with a standard deviation of 3.56% in the period after the crash. It is also more volatile than the Mexican index in all periods, which is in keeping with Diwan, Errunza, and Senbet (1992) who note that a country fund, a derivative asset, is likely to be more volatile than the underlying securities. The volatility of the ADRs from the devloped markets (EuroDR) is of the same order as that of the S&P 500, except in the first sub-period. We note that there was a post-crash increase in the volatility of all the Latin American assets except for the

Argentina Fund (see below). Consistent with the evidence (e.g., Bekaert and Harvey (1994) for emerging markets), the daily returns of the series are not normally distributed, hence, the advantage of using the GMM.

Table 7.1 Summary Statistics for Daily Returns

Index	Mean (%)	Std. Dev.	Skewness*	Kurtosis*	Min.	Max.	p: Mean =0	p: Normal
FULL SAMPLE: Jan. 1992- Dec. 1996 (1245 obs)								
S&P 500	0.044	0.609	- 0.328	1.766	- 3.131	2.112	0.010	0.0001
Latin American ADRs	-0.014	1.690	0.368	5.371	-8.045	11.36	0.775	0.0001
Mexican (Peso) Index	0.055	1.292	0.031	2.680	-5.419	6.791	0.131	0.0001
Mexican ADRs	-0.025	2.094	0.549	6.246	-10.33	15.19	0.671	0.0001
LA ADRs Excl. Mexico	0.024	1.277	0.073	2.956	-5.621	6.552	0.504	0.0001
European ADRs	-0.006	0.925	-0.909	7.971	-9.149	3.563	0.833	0.0001
Argentina Fund	0.022	2.104	0.303	5.009	-13.42	12.75	0.715	0.0001
Chile Fund	-0.008	1.927	-0.058	4.579	-10.43	11.82	0.887	0.0001
Mexico Fund	-0.014	2.639	-13.89	363.4	-68.42	9.764	0.854	0.0001
LA Investment Fund	-0.003	2.334	0.558	3.059	-9.202	13.21	0.959	0.0001
Thai Fund	-0.063	2.825	0.222	10.64	-23.28	23.53	0.433	0.0001
PRE-CRASH PERIOD: Jan. 1992 - Dec. 19, 1994 (740 obs)								
S&P 500	0.011	0.595	-0.160	1.247	-2.429	2.112	0.630	0.0307
Latin American ADRs	0.011	1.550	0.093	2.387	-5.989	7.899	0.848	0.0002
Mexican (Peso) Index	0.058	1.247	-0.282	1.947	-5.419	4.759	0.203	0.0001
Mexican ADRs	0.002	1.765	0.181	2.261	-6.668	9.016	0.972	0.0018
LA ADRs Excl. Mexico	0.046	1.198	-0.063	3.027	-5.621	6.552	0.301	0.0001
European ADRs	-0.040	1.057	-0.890	7.261	-9.149	3.563	0.308	0.0002
Argentina Fund	0.083	2.341	0.354	4.966	-13.42	12.75	0.333	0.0001
Chile Fund	0.052	1.923	0.175	4.182	-9.063	11.82	0.463	0.0001
Mexico Fund	0.090	1.750	0.497	3.089	-7.369	9.263	0.164	0.0001
LA Investment Fund	0.005	2.258	0.281	1.568	-8.456	10.54	0.954	0.0034
Thai Fund	-0.008	2.508	-0.725	11.98	-23.28	13.26	0.927	0.0001
POST-CRASH PERIOD: Dec. 20, 1994 - Dec. 1996 (505 obs)								
S&P 500	0.094	0.627	-0.567	2.561	-3.131	1.925	0.001	0.0001
Latin American ADRs	-0.050	1.877	0.607	7.012	-8.045	11.36	0.551	0.0001
Mexican (Peso) Index	0.051	1.357	0.390	3.411	-5.013	6.791	0.398	0.0001
Mexican ADRs	-0.065	2.500	0.729	6.410	-10.33	15.19	0.556	0.0001
LA ADRs Excl. Mexico	-0.007	1.386	0.219	2.733	-5.138	5.713	0.909	0.0001
European ADRs	0.044	0.684	-0.426	0.998	-2.841	2.180	0.145	0.3601
Argentina Fund	-0.069	1.697	-0.082	1.307	-7.812	5.670	0.365	0.3187
Chile Fund	-0.095	1.931	-0.394	5.138	-10.43	9.878	0.269	0.0001
Mexico Fund	-0.165	3.557	-14.01	269.7	-68.42	9.764	0.297	0.0001
LA Investment Fund	-0.015	2.444	0.880	4.632	-9.202	13.21	0.887	0.0001
Thai Fund	-0.143	3.234	0.892	8.857	-14.76	23.53	0.323	0.0001
Asian ADRs	-0.019	1.057	0.405	2.842	-3.871	5.565	0.683	0.0004

* These are zero for the normal distribution. Standard errors for skewness and kurtosis are approximately the square roots of (6/T) and (24/T), respectively, where T is the number of observations. The p-values indicate the level of significance of tests of difference of mean from zero and normality, respectively. Latin American (LA) ADRs are from Argentina, Chile, and Mexico. 'European' ADRs represent developed markets and are from France, Japan, and the UK. The Thai Fund is used to represent Asian country funds. All returns are in per cent per day.

The daily autocorrelations in the indices are exhibited in Table 7.2 along with the *p*-values of the Ljung-Box test for serial correlation. The Latin American ADRs display a significant daily autocorrelation of 0.091 in the full period. The Mexican component has no statistically significant autocorrelation, whereas the rest of the region's ADRs have a statistically significant 0.182 daily autocorrelation which increases to 0.251 in the post-crash period. The difference between the serial correlation[62] of the latter two markets may reflect the greater trading activity of the Mexican ADRs compared with the others[63].

The cross correlations among the various indices are given in Table 7.3. There is a significant average contemporary correlation of about 35% between the S&P 500 and the Latin American ADRs and less than 20% between the S&P 500 and the country funds.

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[62] The cause of most of the autocorrelation in the emerging markets is quite likely nontrading (and non-synchronous trading). However, the speed of information processing by market participants, day-of-the-week effect (see Akgiray (1989)), bid-ask bounce, price rounding, and the imposition of a ceiling on price changes (see Kim and Rogers (1995)) are secondary factors. The positive (negative) autocorrelation in the returns on stock indices (individual stocks) is a well-documented fact dating back at least to Fama (1965) and Fisher (1966). The papers by Cohen, Hawawini, Maier, Schwartz and Whitcomb (CHMSW) (1980, 1983a, b) and CMSW (1978, 1979, 1986) deal comprehensively with the observed phenomenon, its causes, and consequences. Others such as Scholes and Williams (1977) and Dimson (1979) have developed methods of overcoming the effects of autocorrelation on measuring systematic risk (beta), while several authors like Jokivuolle (1995), Stoll and Whaley (1990a), Blume, MacKinlay, and Terker (1989), and Harris (1989) attempt to correct for autocorrelation in the index by estimating the 'true' unobserved index. Lo and MacKinlay (1990) note that a significant portion of autocorrelation in the (NYSE) index may not be the result of nonsynchronicity. Cutler, Poterba, and Summers (1991) assert that nontrading could not be the cause of autocorrelation they find in markets for foreign exchange, gold, and bonds. But the fact that futures markets tend to be less autocorrelated than spot markets lends support to the nontrading proposition. Roll (1981) notes that the autocorrelation is spurious, merely a consequence of the way records of prices are kept and updated.

[63] Mexican ADRs accounted for 19.7% (28.8%) of total dollar trading volume (share trading volume) of all listed depositary receipts in 1995, compared with 5.7% (7.2%) for Argentina, 4.2 (3.4%) for Chile, and 24.5% (24.4%) for the UK. During this time five of the 10 most actively traded ADRs were from the Latin American region (BNY(1996b)). Using intra-day data, Bailey, Chan, and Chung (1998) find that the Mexican ADRs (e.g., Telemex averages over 2000 daily trades) trade more frequently than the other Latin American stocks (e.g., Telefonos de Chile trades 100 times per day).

Table 7.2 Sample Autocorrelations for Daily Returns

FULL PERIOD: Jan. 1992 - Dec. 1996 (1245 obs)

Lag	SP 500	EuroDR	LATDR	MXADR	XMLADR	ArgFund	ChileFund	MexFund	ThaiFund
1	0.033	-0.039	0.091	0.043	0.182	-0.006	0.118	0.051	0.032
2	0.024	-0.019	-0.009	-0.029	0.020	-0.031	-0.036	0.027	-0.069
3	-0.062	-0.043	0.027	0.011	0.045	0.001	-0.038	-0.010	0.010
4	-0.036	-0.011	0.021	0.022	-0.017	0.030	-0.056	-0.015	-0.026
5	-0.043	-0.056	-0.004	-0.000	-0.036	-0.058	-0.003	-0.021	0.010
LB (6)	0.038	0.080	0.054	0.562	0.000	0.256	0.000	0.525	0.213
LB(12)	0.052	0.072	0.091	0.559	0.000	0.486	0.003	0.661	0.062

PRE-CRASH PERIOD: Jan. 1992 - Dec. 19, 1994 (740 obs)

Lag	SP 500	EuroDR	LATDR	MXADR	XMLADR	ArgFund	ChileFund	MexFund	ThaiFund
1	-0.022	-0.061	0.101	0.008	0.118	-0.047	0.123	0.156	0.110
2	0.022	-0.021	0.004	-0.007	-0.029	-0.060	-0.073	0.019	-0.053
3	-0.063	-0.029	0.001	-0.007	0.075	0.015	-0.038	0.045	-0.025
4	-0.058	0.003	0.039	0.035	0.059	0.055	0.028	0.021	-0.027
5	-0.021	-0.060	-0.018	-0.014	-0.048	-0.068	0.000	-0.015	0.002
LB (6)	0.011	0.210	0.042	0.328	0.003	0.102	0.002	0.002	0.059
LB(12)	0.022	0.231	0.043	0.143	0.001	0.178	0.017	0.001	0.212

POST-CRASH PERIOD: Dec. 20, 1994 - Dec. 1996 (505 obs)

Lag	SP 500	EuroDR	LATDR	MXADR	XMLADR	ArgFund	ChileFund	MexFund	ThaiFund
1	0.094	0.023	0.074	0.008	0.251	0.102	0.107	0.010	-0.040
2	0.019	-0.025	-0.029	-0.051	0.072	0.038	0.015	0.027	-0.086
3	-0.075	-0.098	0.038	0.008	0.011	-0.055	-0.041	-0.033	0.036
4	-0.016	-0.077	-0.013	-0.003	-0.102	-0.051	-0.182	-0.030	-0.039
5	-0.088	-0.051	0.006	0.006	-0.022	-0.028	-0.012	-0.026	0.014
LB (6)	0.054	0.121	0.369	0.706	0.000	0.104	0.000	0.932	0.404
LB(12)	0.215	0.043	0.484	0.883	0.000	0.127	0.002	0.981	0.120

Standard error of the autocorrelation is approximately square root of (1/T), where T is the number of observations. LB(x) is the p-value of the Ljung-Box test of autocorrelation. EuroDR is a portfolio of ADRs from France, Japan, and the UK, LATDR is a portfolio of ADRs from Argentina, Chile, and Mexico, MXADR represents Mexican ADRs, XMLADR represents non-Mexican ADRs from Latin America. XFund is the country fund from country X.

That the S&P 500 leads[64] the portfolio comprised of non-Mexican ADRs by one day may stem from the higher rate of nontrading among the ADRs of Argentina and Chile. The lead might also be due to the fact that during the period under review the domestic markets of Argentina and Chile did not trade concurrently with the US, unlike the Mexican market where for most of the period there was simultaneous trading. The same-day correlation between the S&P 500 and the European ADRs ranges from 47.8% to 50.4%. This seems significantly larger than is the case with the Latin American ADRs, in sympathy with the higher correlation between the indices of developed markets (e.g., 66.1% between Canada and US, Karolyi (1995), see also Karolyi and Stulz (1996) for correlation between Japanese ADRs and various US indices). There is also a strong contemporaneous correlation between the Mexican ADRs and the ADRs from the other Latin American markets.

The Mexican securities lead the others by one day, again an indication of the higher rate of nontrading of the non-Mexican ADRs. As is expected, the Mexican market is highly correlated with its own ADRs and with the ADRs of the other Latin American markets. This may be reflecting the existence of a Latin American factor, proxied by the Mexican market, which aids in the pricing of the region's assets, as asserted by Susmel (1997b) and others.

[64] To test the null of zero cross-correlation, H_0: $\rho_{ij} = 0$, against the alternative H_1: $\rho_{ij} \neq 0$, we reject the null if $\sqrt{T-2}|\hat{\rho}_{ij}|\left(1-\hat{\rho}_{ij}^2\right)^{-0.5} > t_{T-2}(\alpha)$, where $\hat{\rho}$ is the sample correlation, T is the number of observations, and $t_{T-2}(\alpha)$ is the significance point for the t distribution at significance level α using T-2 degrees of freedom (Anderson (1984)).

Table 7.3 Sample Cross-correlations for Daily Returns

Panel A Latin American ADRs

FULL PERIOD: Jan. 1993 - Dec. 1996 (1245 obs)

Lag	SP 500 & MXNDX	SP 500 & L.ATDR	SP 500 & XMLADR	SP 500 & MXADR	MXADR & XMLADR	MXNDX & XMLADR	MXNDX & MXADR
-1	0.074	.028	.086 *	.011	.184 *	.150 *	.080 *
0	0.264*	.369 *	.346 *	.335 *	.460 *	.387 *	.779 *
1	0.017	.032	.015	.024	.035	.078 *	.175 *

PRE-CRASH PERIOD: Jan. 1992 - Dec. 19, 1994 (740 obs)

Lag	SP 500 & MXNDX	SP 500 & L.ATDR	SP 500 & XMLADR	SP 500 & MXADR	MXADR & XMLADR	MXNDX & XMLADR	MXNDX & MXADR
-1	0.104	.068	.141 *	.053	.195 *	.151 *	.074
0	0.251*	.382 *	336 *	.352 *z	.332 *z	.302 *z	.814 *z
1	0.002	.038	-.034	.042	.012	.062	.258 *

POST-CRASH PERIOD: Dec. 20, 1994 - Dec. 1996 (505 obs)

Lag	SP 500 & MXNDX	SP 500 & L.ATDR	SP 500 & XMLADR	SP 500 & MXADR	MXADR & XMLADR	MXNDX & XMLADR	MXNDX & MXADR
-1	0.082	.016	.022	-.030	.170 *	.140 *	.076 *
0	0.278*	.362 *	.364 *	.329 *z	.579 *z	.488 *z	.760 *z
1	0.045	.027	.076 *	.008	.054	.097 *	.102 *

Panel B "European" ADRs and Emerging Market Country Funds

FULL PERIOD: Jan. 1992- Dec. 1996 (1245 obs)

Lag	SP 500 & EuroDR	SP 500 & LAIFund	EuroDR & XMLADR	EuroDR & MXADR	SP 500 & ArgFund	SP 500 & Chile Fund	SP 500 & Mexico Fund	SP 500 & Thai Fund
-1	-0.031	0.057	0.063	0.027	0.096 *	0.118 *	0.065	0.002
0	0.478*	0.225*	0.265*	0.193*	0.113 *	0.228 *	0.146 *	0.271*
1	0.003	0.060	-0.005	-0.011	-0.037	-0.020	0.017	0.015

PRE-CRASH PERIOD: Jan. 1992 - Dec. 19, 1994 (740 obs)

Lag	SP 500 & EuroDR	SP 500 & LAIFund	EuroDR & XMLADR	EuroDR & MXADR	SP 500 & ArgFund	SP 500 & Chile Fund	SP 500 & Mexico Fund	SP 500 & Thai Fund
-1	-0.056	0.107	0.113*	0.053	0.107*	0.144*	0.146*	0.038
0	0.481*	0.183	0.307*	0.249*zz	0.096*	0.242*	0.242*z	0.288*
1	-0.039	0.007	-0.041	-0.044	-0.058	-0.059*	-0.048	0.012

POST-CRASH PERIOD: Dec. 20, 1994 - Dec. 1996 (505 obs)

Lag	SP 500 & EuroDR	SP 500 & LAIFund	EuroDR & XMLADR	EuroDR & MXADR	SP 500 & ArgFund	SP 500 & Chile Fund	SP 500 & Mexico Fund	SP 500 & Thai Fund
-1	0.013	0.071	-0.023	-0.004	0.088*	0.089*	0.021	-0.035
0	0.504*	0.060	0.218*	0.143*zz	0.159*	0.216*	0.101*z	0.261*
1	0.082	-0.010	0.068	0.047	0.007	0.040	0.069	0.020

*Significant at the 0.05 level. z (zz): Fisher z statistic rejects the null hypothesis of equal unconditional correlation between two series across the two sub-periods at the 0.05 (0.10) level. EuroDR represents ADRs from France, Japan, and the UK, LATDR is a portfolio of ADRs from Argentina, Chile, and Mexico, MXADR (MXNDX) represents the Mexican ADRs (index), and XMLADR represents Latin America non-Mexican ADRs. XFund is the country fund from country X and LAIFund is the multi-country L. A. Investment Fund.

It is evident that the period after the peso crash was one of higher-than-usual volatility in Latin America. For instance, the standard deviation of the Mexican ADRs increased by 42% and that of the non-Mexican ADRs market by 16%. The volatility of the Mexican peso index experienced an increase of 9% (see Table 7.1). During this time the volatility of the ADRs from the developed markets declined while the S&P 500 evidenced only a small increase. The empirical evidence (see e.g., Roll (1989)) that an increase in the volatility of one market can lead to higher levels of unconditional correlation with others is reflected in the increase in the correlation between the Mexican and other Latin American ADRs (0.332 to 0.579) and between the Mexican index and the non-Mexican ADRs (0.302 to 0.488) over the two sub-periods. The Fisher z statistic (Anderson (1984))[65] rejects the null hypothesis of no change in the unconditional correlation across sub-periods at the 5% level. Equally significant is the reduction in correlation between the S&P 500 and the Mexican ADRs and between the Mexican index and the Mexican ADRs.

III. B. Main Results

Tables 7.4 to 7.6 display the results for the tests when the US investor holds the S&P 500, the S&P 500 and the risk-free asset, and the S&P 500 with the ADRs from the developed markets, respectively.

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65 Let $z = \frac{1}{2}\log\frac{1+\hat{\rho}}{1-\hat{\rho}}$, $\hat{\rho}_i$ equal the sample correlation in period i, T_i the sample size in sub-sample i, and z_i the statistic in period i, i=1,2. If the null hypothesis of equal correlation across periods is true then z_1-z_2 is asymptotically ~ N(0, $1/(T_1$-3)+$1/(T_2$-3)). At the 0.05 level the critical region is: $|z_1 - z_2|(1/(T_1-3)+1/(T_2-3))^{-0.5} > 1.96$.

Unconditional Mean-Variance Spanning. The unconditional results for both ADRs and country funds are reported in Table 7.4, but in Tables 7.5 and 7.6 I report unconditional results only for the ADRs. There is a strong similarity across all portfolios of test assets as neither the ADRs nor the country funds provide diversification for any of the three portfolios of spanning assets in the full period, the full period with the crash excluded, and the pre-crash period. That is, the US domestic investment in the S&P 500, in the S&P 500 and the risk-free security, and in the portfolio of the S&P 500 and the European ADRs span the portfolios of the Latin American ADRs and country funds so that the addition of the latter portfolios does not provide diversification for the US investor who follows a 'buy and hold' portfolio strategy. For instance, in the full period the Mexican ADRs have *p*-values of 0.169, 0.220, and 0.188, (first column, Tables 7.4-7.6), thus we cannot reject the null hypothesis that the benchmark portfolios span the Latin American ADRs.

Furthermore, neither the portfolio of "European" ADRs (EuroDR) when used as test assets against the two domestic portfolios (Tables 7.4 and 7.5), nor the Thai country fund (representing Asian funds) against all three portfolios, benefits the investor. However, in the post-crash period the full set of Latin American ADRs (*p*-value = 0.048) and the Thai fund (*p*-value = 0.045) provide diversification when the investment is comprised of the S&P 500. That is, we reject the null hypothesis that the S&P 500 spans the ADRs or Thai Fund, respectively.

In the post-crash period, investing in the Latin American ADRs diversified the investor's portfolio of the S&P 500 and the EuroDR (*p*-value = 0.047, Table 7.6).

Table 7.4 Mean-Variance Spanning Tests: S&P 500 vs. Latin American Assets

The conditional model is: $E\left[\left(R_{2,t} - B(R_{1,t})\right) \otimes (R_{1,t}) \otimes \mathbf{Z}_{t-1}\right] = 0$ and $\Sigma_{j=1}^{K} b_{ij} = 1$, where $i = K+1,\ldots,N$, the test assets, and $j = 1,\ldots, K$, the spanning assets. $R_{1,t}$ is the daily return on the S&P 500 (the *spanning asset*), $R_{2,t}$ is a portfolio of ADRs or country funds (CECFs) (the *test asset*). Z is a T×L matrix of instruments including a constant, lagged returns on the S&P 500, lagged returns on the Mexican (peso) index, and the lagged changes in the daily peso/dollar exchange rate. When the test assets are European ADRs the instruments are the constant, the S&P 500, and the lagged change in the dollar/pound exchange rate. *The table presents a test of whether or not a benchmark portfolio of the S&P 500 spans a portfolio of ADRs or CECFs* . The test statistic [p-value] is the number of observations times the minimized objective value of the GMM, which is approximately chi-square distributed with degrees of freedom based on (N-K) × K (unconditional) or (N-K) × K× L (conditional) orthogonality conditions and (N-K) × (K-1) unknown parameters.

Spanning Asset: S&P 500

Test Assets (ADRs)	Unconditional (1)	Conditional (4)*	Test Assets (Country funds)	Unconditional (1)	Conditional (4)
		January 1992 to December 1996 (T=1244)			
LATDR	1.790[0.181]	9.961[0.419]	LA Invest. Fund	0.421[0.516]	8.132[0.087]
XMLADR	0.545[0.815]	16.323[0.003]	Argentina Fund	0.006[0.938]	13.085[0.011]
MXADR	1.892[0.169]	7.505[0.111]	Mexico Fund	0.342[0.559]	7.897[0.095]
			Chile fund	0.556[0.456]	16.786[0.002]
EuroDR	2.592[0.107]	6.765[0.080]	Thai Fund	2.446[0.118]	5.889[0.209]
		Exclusion of Mexican Peso Crash Period (Dec. 20 to 31, 1994) (T= 1238)			
LATDR	1.572[0.210]	12.408[0.015]	LA Invest. Fund	0.297[0.586]	9.191[0.056]
XMLADR	0.000[0.996]	15.448[0.004]	Argentina Fund	0.003[0.956]	14.027[0.007]
MXADR	1.402[0.236]	9.722[0.045]	Mexico Fund	0.281[0.596]	7.296[0.121]
			Chile fund	0.354[0.552]	15.877[0.003]
EuroDR	2.710[0.100]	7.014[0.071]	Thai Fund	2.300[0.129]	8.040[0.090]
		Pre-Peso Crash: Jan. 1992 to Dec. 19, 1994 (T=739)			
LATDR	0.000[0.993]	6.992[0.136]	LA Invest. Fund	0.001[0.975]	10.125[0.038]
XMLADR	0.854[0.356]	25.915[0.000]	Argentina Fund	0.860[0.354]	10.523[0.032]
MXADR	0.021[0.886]	4.683[0.321]	Mexico Fund	1.732[0.188]	17.986[0.001]
			Chile fund	0.404[0.525]	14.490[0.006]
EuroDR	2.021[0.155]	1.826[0.611]	Thai Fund	0.058[0.810]	5.895[0.207]
		Post-Peso Crash: Dec. 20, 1994 to Dec. 1996 (T=505)			
LATDR	3.918[0.048]	3.802[0.433]	LA Invest. Fund	1.307[0.253]	6.111[0.191]
XMLADR	2.082[0.149]	10.749[0.030]	Argentina Fund	2.089[0.148]	7.400[0.116]
MXADR	3.333[0.068]	3.255[0.516]	Mexico Fund	2.245[0.134]	2.242[0.691]
			Chile fund	3.492[0.062]	7.273[0.122]
EuroDR	0.073[0.787]	1.580[0.664]			
EMADR	1.917[0.166]	16.995[0.002]	Thai Fund	4.012[0.045]	2.617[0.624]

Latin American ADRs (LATDR) are exchange-listed ADRs from Argentina, Chile, and Mexico. XMLADR are Latin American ADRs excluding those from Mexico (MXADR). European ADRs (EuroDR) are a portfolio of ADRs from France, Japan, and the UK. EMADR are ADRs from Asian emerging markets. * : (degree of freedom) in brackets. The degree of freedom of the conditional model of the European ADRs is (3).

There is weak evidence (p-values of 0.068 and 0.067) that the Mexican ADRs provide diversification for the S&P 500 and for the S&P 500 with the European ADRs in the post-crash period. The ADRs from Asian emerging markets[66] do not provide diversification in the unconditional tests.

Conditional Spanning. The top two panels of Table 7.4 indicate that when the US investment is comprised solely of the S&P 500 most of the test assets provide significant diversification in the full period and in the full period with the first 10 days after the crash excluded. In Table 7.4 the portfolio of non-Mexican ADRs (XMLADR) (p-values = 0.003 and 0.004, first two panels respectively), the Mexican ADRs (p-value = 0.045 in the second panel), and the full set of ADRs (LATDR) (p-value = 0.015 in the second panel) diversified the investor's portfolio. Among the country funds, Argentina (p-values = 0.011 and 0.007) and Chile (p-values = 0.002 and 0.003) provide diversification. Investing in the other country funds resulted in only marginal gains. When the US investor expands her holdings to include the domestic risk-free asset (Table 7.5, first two panels) only the Chile fund (in the full period) provides significant diversification, while several other assets had marginal results. In Table 7.6 (first two panels), when the EuroDRs are added to the S&P 500, neither the Latin American ADRs nor country funds provide diversification for the investor. Additionally, the investor does not obtain diversification from investing in the Asian (Thai) fund in any of these two periods.

66 The post-crash period is used because the sample of ADRs listed prior to the crash is too small for making inferences.

The sub-period results are the most interesting in light of the main objective of this paper and form the bulk of the remaining analyses. When the S&P 500 is the only spanning asset (Table 7.4, bottom two panels), investing in the Mexican ADRs do not provide diversification for the investor in either sub-period. The impact of the crash on these ADRs is not clear-cut in light of the significant result registered in the full period excluding the crash (p-value = 0.045). On the other hand, the non-Mexican ADRs (XMLADR) provide significant diversification in both the pre-crash (p-value = 0.000) and the post-crash (p-value = 0.030) periods. Investing in the combined portfolio of Latin American ADRs (LATDR) do not benefit the investor, reflecting the influence of the Mexican assets. All the country funds provide substantial diversification in the pre-crash period but this completely disappears after the peso crisis. For example, the multi-country Latin American Investment Fund has p-values = 0.038 and 0.191 in the two sub-periods, respectively, the Argentina Fund has p-values = 0.032 and 0.116, the Mexico Fund has p-values = 0.001 and 0.691, and the Chile Fund has p-values = 0.006 and 0.122.

In Table 7.5, where the domestic portfolio now includes the S&P 500 and the risk-free asset, the pattern of diversification is repeated, albeit for fewer assets. The non-Mexican ADRs (XMLADR) (p = 0.001) provide diversification in the pre-crash period, but this benefit ceased after the peso crash (p = 0.157). In the case of the country funds, Mexico significantly (p = 0.034) and Chile marginally (p = 0.052) diversify the US investor's portfolio in the pre-crash period. There is no diversification in the post-crash period from any country fund.

Table 7.5 Mean-Variance Spanning Tests: S&P 500 and Risk-free Asset vs. Latin American Assets

The conditional model is: $E\left[\left(R_{2,t} - B\begin{bmatrix} R_{0,t} \\ R_{1,t} \end{bmatrix}\right) \otimes \begin{bmatrix} R_{0,t} \\ R_{1,t} \end{bmatrix} \otimes \mathbf{Z}_{t-1}\right] = 0$ and $\Sigma_{j=1}^{K} b_{ij} = 1$, where $i = K+1, \ldots, N$, the test assets, and $j = 1, \ldots, K$, the spanning assets. $R_{0,t}$ is the risk-free asset proxied by Fed funds daily rate and $R_{1,t}$ is the daily return on the S&P 500 (the *spanning assets*). $R_{2,t}$ is a portfolio of ADRs or country funds (CECFs) (the *test assets*). **Z** is a T×L matrix of instruments including a constant, lagged returns on the S&P 500, lagged returns on the Mexican (peso) index, and the lagged changes in the daily peso/dollar exchange rate. When the test assets are European ADRs the instruments are the constant, the S&P 500, and the lagged changes in the dollar/pound exchange rate. *The table presents a test of whether or not a benchmark portfolio of the S&P 500 and a risk-free asset span a portfolio of ADRs or CECFs.* The test statistic [p-value] is the number of observations times the minimized objective value of the GMM, which is approximately chi-square distributed with degrees of freedom based on (N-K) × K (unconditional) or (N-K) × K× L (conditional) orthogonality conditions and (N-K) × (K-1) unknown parameters.

Spanning Asset: S&P 500 and Risk-free Asset

Test Assets (**ADRs**)	Unconditional (1)	Conditional (7)*	Test Assets (**Country funds**)	Conditional (7)
		January 1992 to December 1996 (T=1244)		
LATDR	1.924[0.165]	10.508[0.162]	LA Invest. Fund	8.093[0.324]
XMLADR	2.598[0.107]	13.203[0.067]	Argentina Fund	12.712[0.079]
MXADR	1.506[0.220]	7.956[0.336]	Mexico Fund	7.243[0.404]
			Chile fund	14.948[0.037]
EuroDR	0.231[0.631]	6.474[0.263]	Thai Fund	5.708[0.574]
		Exclusion of Mexican Peso Crash Period (Dec. 20 to 31, 1994) (T= 1238)		
LATDR	1.071[0.301]	13.053[0.071]	LA Invest. Fund	8.844[0.264]
XMLADR	1.981[0.159]	12.804[0.077]	Argentina Fund	13.143[0.069]
MXADR	1.079[0.299]	10.051[0.186]	Mexico Fund	6.477[0.485]
			Chile fund	13.689[0.057]
EuroDR	0.210[0.648]	6.710[0.243]	Thai Fund	7.968[0.335]
		Pre-Peso Crash: Jan. 1992 to Dec. 19, 1994 (T=739)		
LATDR	0.983[0.321]	7.030[0.426]	LA Invest. Fund	9.649[0.209]
XMLADR	1.442[0.230]	24.118[0.001]	Argentina Fund	9.551[0.215]
MXADR	0.856[0.355]	4.754[0.690]	Mexico Fund	15.180[0.034]
			Chile fund	13.929[0.052]
EuroDR	0.038[0.845]	0.369[0.996]	Thai Fund	5.975[0.543]
		Post-Peso Crash: Dec. 20, 1994 to Dec. 1996 (T=505)		
LATDR	0.003[0.956]	3.753[0.808]	LA Invest. Fund	5.915[0.550]
XMLADR	0.000[0.987]	10.593[0.157]	Argentina Fund	7.984[0.334]
MXADR	0.000[0.995]	3.220[0.864]	Mexico Fund	2.307[0.941]
			Chile fund	7.751[0.355]
EuroDR	0.015[0.903]	1.427[0.921]		
EMADR	1.961[0.161]	10.953[0.141]	Thai Fund	2.467[0.930]

Latin American ADRs (LATDR) are exchange-listed ADRs from Argentina, Chile, and Mexico. XMLADR are Latin American ADRs excluding those from Mexico (MXADR). European ADRs (EuroDR) are a portfolio of ADRs from France, Japan, and the UK. EMADR are ADRs from Asian emerging markets. *: (degree of freedom) in brackets. The degree of freedom of the conditional model of the European ADRs is (5).

Table 7.6 Are Latin American ADRs and Country Funds Spanned by the US and European Assets?

The main conditional model is: $E\left[\left(R_{3,t}-B\begin{bmatrix}R_{1,t}\\R_{2,t}\end{bmatrix}\right)\otimes\begin{bmatrix}R_{1,t}\\R_{2,t}\end{bmatrix}\otimes Z_{t-1}\right]=0$ and $\Sigma_{j=1}^{K}b_{ij}=1$, where $i=K+1,\ldots,N$, the test assets, and $j=1,\ldots,K$, the spanning assets. $R_{1,t}$ is the daily return on the S&P 500 and $R_{2,t}$ is the portfolio of European ADRs (the *spanning assets*). $R_{3,t}$ is a portfolio of ADRs or country funds (the *test assets*). **Z** is a T×L matrix of instruments including a constant, lagged returns on the S&P 500, the lagged changes in the daily dollar/pound exchange rate, lagged returns on the Mexican (peso) index, and the lagged changes in the daily peso/dollar exchange rate. *The table presents a test of whether or not a benchmark portfolio of the S&P 500 and the European ADRs span a portfolio of Latin American ADRs or country funds.* The test statistic [p-value] is the number of observations times the minimized objective value of the GMM, which is approximately chi-square distributed with degrees of freedom based on (N-K) × K× L (conditional) orthogonality conditions and (N-K) × (K-1) unknown parameters.

Spanning Asset: S&P 500 and European ADRs

Test Assets (ADRs)	Unconditional (1)	Conditional (9)*	Test Assets (Country funds)	Conditional (9)
January 1992 to December 1996 (T=1244)				
LATDR	1.529[0.216]	10.670[0.299]	LA Invest. Fund	6.931[0.644]
XMLADR	0.001[0.975]	13.525[0.140]	Argentina Fund	12.682[0.178]
MXADR	1.731[0.188]	9.274[0.412]	Mexico Fund	6.986[0.639]
			Chile fund	11.630[0.235]
			Thai Fund	9.745[0.372]
Exclusion of Mexican Peso Crash Period (Dec. 20 to 31, 1994) (T= 1238)				
LATDR	1.017[0.313]	12.871[0.169]	LA Invest. Fund	7.039[0.633]
XMLADR	0.042[0.838]	13.408[0.145]	Argentina Fund	14.566[0.104]
MXADR	1.256[0.262]	12.254[0.199]	Mexico Fund	6.479[0.691]
			Chile fund	11.240[0.260]
			Thai Fund	14.544[0.104]
Pre-Peso Crash: Jan. 1992 to Dec. 19, 1994 (T=739)				
LATDR	0.032[0.858]	2.133[0.989]	LA Invest. Fund	8.508[0.484]
XMLADR	1.413[0.235]	6.951[0.642]	Argentina Fund	10.885[0.284]
MXADR	0.000[0.999]	1.766[0.995]	Mexico Fund	8.148[0.519]
			Chile fund	6.077[0.732]
			Thai Fund	1.722[0.995]
Post-Peso Crash: Dec. 20, 1994 to Dec. 1996 (T=505)				
LATDR	3.930[0.047]	2.077[0.990]	LA Invest. Fund	4.099[0.905]
XMLADR	2.051[0.152]	7.504[0.585]	Argentina Fund	9.630[0.381]
MXADR	3.360[0.067]	1.800[0.994]	Mexico Fund	2.609[0.978]
			Chile fund	8.660[0.469]
EMADR	1.855[0.173]	17.968[0.036]	Thai Fund	1.348[0.998]

Latin American ADRs (LATDR) are exchange-listed ADRs from Argentina, Chile, and Mexico. XMLADR are Latin American ADRs excluding those from Mexico (MXADR). European ADRs (EuroDR) are a portfolio of ADRs from France, Japan, and the UK. EMADR are ADRs from Asian emerging markets. *: (degree of freedom) in brackets.

In Table 7.6, when the investor augments the S&P 500 with the EuroDR this portfolio spans all Latin American assets in both the pre- and post-crash sub-periods (and for all periods).

For similar assets that are not from the Latin American region, Table 7.4 shows that the ADRs from the developed markets (EuroDR) when used as test assets marginally diversify the investor's portfolio over the longer periods. They do not do so in any of the sub-periods nor with the portfolio including the risk-free asset (Table 7.5). Investing in the Thai fund failed to significantly improve the investor's reward-to-risk ratio in any period for any of the investor's portfolios. However, the portfolio of Asian ADRs (EMADR) provides diversification in the post-crash period when the investor holds the S&P 500 (p = 0.002) and when she includes the EuroDR (p = 0.036), but not when she invests jointly in the S&P 500 and the risk-free asset (p = 0.141).

Several conclusions arise from the preceding results. The cataclysmic events of December 1994 have severe consequences for the strategy of international portfolio diversification into the Latin American market. First, investing in the ADRs and country funds of Latin America significantly benefited the US investor who held domestic assets in the pre-crash period. However, the rewards of diversification, in the main, disappeared after the peso crisis. Second, it appears that the crisis impaired the capacity of the country funds to provide international diversification more than it did the ADRs. Third, it appears that the onset of the Mexican peso crash caused sufficient concerns about the other Latin American markets to the extent that the latter no longer provided diversification after the crash. The significant post-crash increase in the unconditional correlation between the Mexican and non-Mexican ADRs and between the Mexican index and ADRs (Table 7.3) support this. Fourth, if the investor had already invested in ADRs from the developed markets (earning at best only marginal international diversification), then the Latin American assets would not have provided further diversification in any period. Finally, it is clear that the results concerning the Latin American assets are not driven by a global phenomenon that impacted on all ADRs and country funds. The question that now arises is how can we explain the pattern of changes in the diversification provided by these assets?

III. C. Explaining the Pattern of Diversification

In this section I attempt to explain why Latin America's securities provided diversification to the US investor before but not after the peso crash. Before doing so, however, we should consider some factors that are not related to the existence of diversification but which could influence the results. For instance, the asymptotic assumptions of the chi-squared tests could be violated by the finite sample size. However, with over 500 returns in each sub-period and a maximum of two parameters, the finite sample size raises no serious concern. Similarly, the possibility of non-stationarity of the returns on the variables and the instruments is another concern. However, because all the analyses use returns (log-price difference) and not prices, nonstationarity is also not a major issue. This is supported by Augmented Dickey-Fuller tests for unit roots (not reported). We can infer that the selected instruments are not poor instruments for the returns on the test and spanning assets by referring to the regressions in Tables 7.7 and 7.8 where we find several individually significant coefficients and significant robust Wald tests of groups of parameters. Therefore, there is no evidence that the results are a function of any violation of the assumptions underlying the GMM. However, the existence of a factor specific to country funds that is not spanned by the benchmark equities could lead to a rejection of the null hypothesis in the case of the country funds. That is, the correct comparator in that case would have been a US (developed market) fund since there could be a rejection of the null hypothesis due solely to that factor and less to do with diversification. Given the similarity of the results using ADRs and country funds, there appears to be no such factor (see Bekaert and Urias (1995)).

Post-Crash Dynamics of the Conditioning Instruments. One possible explanation for the results that the Latin American country funds and the non-Mexican ADRs (when the investor also holds the risk-free asset) provide diversification for the US investor in the pre- but not the post-crash period may be found in the dynamics of the conditioning instruments and the spanning assets. When returns are conditioned on a set of information variables, the product of the variables and the vector of returns (i.e., $\mathbf{R}_{i,t} \otimes \mathbf{Z}_{t-1}$) represents scaled returns. The vector of information instruments represents the proportion of the investor's funds allocated to the asset, based on the information available at time t-1. If the covariance between the instruments and the spanning assets (e.g., the S&P 500) are time-varying, then the composition of the investor's portfolio will also be time-varying.

Therefore, that the Latin American assets performed differently across sub-periods may be accounted for by this changing covariance. I, therefore, analyze the dynamics between the main instrument (the Mexican index) and the main spanning asset (the S&P 500) to determine if their conditional means, variances, and the conditional covariance between them are time-varying and if their dynamics were affected by the peso crash and the resulting increase in exchange rate volatility.

I use the following bivariate GARCH(1,1) model which is an adaptation of the constant correlation model of Bollerslev (1990) but allowing for time-variation in the conditional covariance (7.11):

$$R_{i,t} = b_0 + \mathbf{X'B} + \varepsilon_{i,t} \tag{7.9}$$

$$h_{i,t} = c + a\varepsilon^2_{i,t-1} + bh_{i,t-1} + \mathbf{Z'D} \tag{7.10}$$

$$h_{ij,t} = (r_0 + r_1 CRASH_t + r_2 ABMEXFX_{t-1}) * [\sqrt{h_{i,t}}\sqrt{h_{j,t}}]. \tag{7.11}$$

ABMEXFX[67] is the absolute value of DMEXEXCH, the daily change in the peso/dollar exchange rate. Absolute values are used to represent the volatility of a series. CRASH is an indicator dummy where one represents the post-crash period and zero otherwise (see relevant tables for variables in vectors **X** and **Z**). Equation (7.11) is the conditional covariance model where r_0 is the estimate of the constant correlation between the two variables, and r_1 and r_2 are coefficients. To explain the

[67] In this and the next test ABMEXFX is used to gauge the extent to which conditional covariance changed with peso volatility. This captures the change in volatility after the crash since there was very little variation prior to the crash. However, when the interaction variable CRASH*ABMEXFX was used there was no significant difference in the mean and variance equations, but the interaction coefficient was insignificantly negative while the CRASH had coefficient 0.098 (p-value = 0.065). In the next test the interaction coefficient was insignificant but the diagnostics were less precise.

pattern of diversification we need to show that the conditional covariance changed after the crash and/or as a result of the change in the exchange rate volatility. That is, the coefficients on the crash dummy and/or on the exchange rate volatility need to be (significantly) non-zero. This would then support a change in the portfolio composition after the crash which may have resulted in the failure to find diversification in the post-crash period. The model is estimated by maximizing the sample log likelihood for each period t:

$$L_t(\Phi) = -\tfrac{1}{2}\log\left|\mathbf{H}_t\right| - \tfrac{1}{2}\varepsilon_t'(\Phi)\mathbf{H}_t^{-1}(\Phi)\varepsilon_t(\Phi) \tag{7.12}$$

and over the sample period

$$L(\Phi) = \sum_{t=1}^{T} L_t(\Phi) \tag{7.13}$$

where $\mathbf{\Phi}$ is the vector of parameters[68].

The results are in Table 7.7 and given the focus of this enquiry, the analysis covers only the conditional covariance equation. The exchange rate volatility has a coefficient significantly different from zero (-0.058, t = -4.983) while the crash dummy is insignificant (0.034, t = 0.756). Therefore, the conditional covariance between the Mexican index, one of the main information variables, and the S&P 500, the primary spanning asset, suggests that the scaled returns changed as a result of the increase in peso volatility following the crash. In other words, the pattern of diversification might have resulted from time-variation in the composition of the investor's portfolio brought on by the increased currency volatility.

[68] I use the Broyden, Fletcher, Goldfarb, and Shanno (BFGS) algorithm with a variance-covariance matrix robust to non-normality instead of the popular Berndt, Hall, Hall, and Hausman (BHHH) (1974)) algorithm. This produces quasi-maximum likelihood (QML) estimates asymptotically equivalent to Bollerslev and Wooldridge (1992).

Table 7.7 Test of Time-Variation in the Relation Between the Conditioning and Spanning Instruments

The Mexican Index equations are:

$R_{i,t} = b_0 + b_1\ SP5NDX_{t-1} + b_2\ DMEXEXCH_{t-1} + b_3\ MXNDX_{t-1} + b_4 MXNDX_{t-2} + b_5 CRASH + e_t$

$h_{i,t} = c + a\ (e^2_{i,t-1}) + b\ h_{i,t-1} + d_1\ ABMEXFX_{t-1} + d_2\ ABSP5NDX_{t-1} + d_3\ CRASH$

$h_{i,j,t} = (r_0 + r_1 CRASH + r_2\ ABMEXFX_{t-1})*(\sqrt{h_{i,t}}\ \sqrt{h_{j,t}})$

ABMEXFX is the absolute value of DMEXEXCH (the peso/dollar changes), ABMXNDX is the absolute value of MXNDX (the returns on the Mexican index), and ABSP5NDX is the absolute value of SP5NDX (the returns on the S&P 500 index). The variables in the mean of the S&P 500 are three own lags, MONDAY and CRASH (both indicator dummy variables), respectively. The exogenous variables in the variance are lagged ABMEXFX, lagged ABMXNDX, and CRASH, respectively. Parameters (robust t-statistics) are estimated using quasi-maximum likelihood estimation.

Panel A Conditional Mean Equations

	b_0	b_1	b_2	b_3	b_4	b_5
Mexican Index	0.088 (3.301)	0.084 (1.417)	-0.012 (-0.267)	0.201 (4.185)	0.008 (0.146)	-0.013 (-0.324)
S&P 500	0.003 (0.157)	0.035 (1.049)	0.021 (0.723)	-0.063 (-2.438)	0.121 (2.043)	0.078 (2.446)

Panel B Conditional Variance Equations

	c	a	b	d_1	d_2	d_3
Mexican Index	0.172 (0.776)	0.162 (1.232)	0.728 (2.459)	0.138 (0.550)	-0.068 (-0.669)	-0.044 (-0.531)
S&P 500	0.038 (3.172)	0.051 (1.521)	0.841 (9.686)	-0.007 (-4.639)	0.000 (0.021)	0.008 (0.670)

Panel C Conditional Covariance Equation

	r_0	r_1 (Crash)	r_2 (Abs. Exch. Rate)
Augmented "Crash and Exchange Rate" Model	0.308 (6.570)	0.034 (0.756)	-0.058 (-4.983)

Panel D Diagnostics

	Mexican (Peso) Index		S&P 500
Loglikelihood		-716.175	
Autocorrelation in standardized residuals			
p-value: Ljung-Box Q(6), Q(12) - residuals	(0.461) (0.509)		(0.249) (0.304)
p-value: Ljung-Box Q(6), Q(12) - squared residuals	(0.810) (0.471)		(0.259) (0.401)
p-value: Ljung-Box Q(6), Q(12) - crossproduct		(0.313) (0.243)	
Normality of standardized residuals			
p-value: Jarque-Bera (Normal) Stats	0.000		0.000
p-value: skewness	0.058		0.000
p-value: kurtosis	0.000		0.000
Robust Wald tests			
p-value: constant variance in the equations		0.000	
p-value: constant mean in the equations		0.000	
p-value: significance of coefficients in covariance equation.		0.000	

Several other specifications of the equations were tested. For instance, specifications in which the crash and peso volatility variables were introduced one at a time made no difference to the result. However, when the exchange rate and the crash dummy were removed from the mean and variance equations, the conditional covariance equation had coefficients 0.269 (t = 8.943), 0.079 (t = 1.554), and -0.030 (t = -1.610) for the constant correlation, the crash dummy and the absolute exchange rate changes, respectively. We conclude, therefore, that there is limited support for the proposition that the time-variation of the instruments and their relation with the spanning asset gave rise to the pattern of diversification.

Post-Crash Dynamics of the Spanning and Test Assets. In periods of high volatility there is increased correlation between national markets (e.g., Ross (1988, 1989), Ramchand and Susmel (1997)). If the conditional covariance between the Latin American assets and the S&P 500 increased significantly as a result of the greater regional volatility after the crash, then this, in part, provides an explanation for the lack of diversification observed in the post-crash period. On the other hand, this view is tempered by another volatility-related argument by Karolyi and Stulz (1996). They point out that "...it is not necessarily the case that a higher conditional variance in one market or the other implies a higher conditional covariance between these markets. If the *competitive shock* component in the conditional covariance dominates, a high conditional variance of the competitive shock is associated with a low conditional covariance." The large devaluation of the peso around December 1994 is, in the framework of Karolyi and Stulz, considered to be a competitive shock. For instance, if this shock led to similar devaluation in the other Latin American economies, then their exports would become more competitive in the US market.

To investigate if the conditional covariance between the country funds and non-Mexican ADRs, respectively, and the S&P 500 changed after the crash, I use the GARCH(1,1) model outlined above. The results in Table 7.8 (where the conditioning variables are explained) indicate that the conditional covariance between the non-Mexican ADRs and the S&P 500 increased from a significant 0.334 (t = 15.18) to 0.451 as a result of an increase of 0.117 (t = 4.365) after the peso crash. There is, however, a decline of 0.075 (t = -154.6) which is attributed to an increase in the exchange rate volatility.

The multi-country, Latin American Investment Fund experienced an increase in covariance from a significant 0.180 (t-value = 5.914) to 0.349 as a result of an increase of 0.169 (t-value = 3.381) after the crash. There was a small but insignificant decrease as a result of a change in the peso/dollar volatility.

There is strong evidence, therefore, that the failure to obtain diversification from investing in the region's ADRs and country funds in the post-crash period is caused in part by an increase in the conditional correlation between the latter instruments and the S&P 500 in this period. The question arises as to whether the increase in the conditional correlation between these emerging markets and the US market came about as a result of some temporary phenomenon related to the increased volatility

Table 7.8 Tests of Constant Conditional Correlation Between Test and Spanning Assets

The equations for the non-Mexican Latin American ADRs and the multi-country Latin American Investment Fund are:

$R_{i,t} = b_0 + b_1 R_{it-1} + b_2\, DMEXEXCH_{t-1} + b_3\, MXNDX_{t-1} + b_4\, MXNDX_{t-2} + b_5\, CRASH + e_t$

$h_{i,t} = c + a\,(e^2_{i,t-1}) + b\, h_{i,t-1} + d_1\, ABMEXFX_{t-1} + d_2\, ABMXNDX_{t-1} + d_3\, CRASH$

$h_{i,j,t} = (r_0 + r_1 CRASH + r_2\, ABMEXFX_{t-1})*(\sqrt{h_{i,t}}\sqrt{h_{j,t}})$

Two bivariate models, one each containing the S&P 500 and one Latin American asset, were done. To conserve space the table reports the results for only one S&P 500 model since the results are similar in both cases.

ABMEXFX is the absolute value of DMEXEXCH (the peso/dollar changes) and ABMXNDX is the absolute value of MXNDX (the return on the Mexican index). The S&P 500 return variables are three own lags (SP5NDX), lagged MXNDX, and CRASH (indicator dummy). The exogenous variables in the variance are ABMEXFX, ABMXNDX, and CRASH. Parameters (robust *t*-statistics) are estimated using robust quasi-maximum likelihood estimation.

Panel A Conditional Mean Equations

	b_0	b_1	b_2	b_3	b_4	b_5
non-Mex. ADRs	0.059(2.503)	0.114(3.750)	-0.117(-5.882)	0.109(4.425)	0.002(0.088)	-0.006(-0.146)
L.A. Inv. Fund		-0.035(-1.218)	-0.043(-1.112)	0.118(3.843)	-0.0167(-0.314)	-0.014(-0.189)
S&P 500	0.016(1.095)	0.025(0.924)	0.020(0.835)	-0.074(-3.028)	0.004(0.317)	0.103(4.730)

Panel B Conditional Variance Equations

	c	a	b	d_1	d_2	d_3
non-Mexican ADRs	0.037(1.096)	0.068(2.757)	0.877(22.79)	0.058(1.874)	0.031(1.114)	-0.018(-1.286)
L.A. Investment Fund	0.645(9.941)	0.163(7.890)	0.641(51.65)	0.623(2.934)	0.330(4.308)	-0.306(-2.906)
S&P 500	0.017(0.922)	0.030(1.447)	0.922(13.54)	-0.004(-1.594)	0.000(0.068)	0.003(0.722)

Panel C Conditional Covariance Equation

	r_0	r_1 (crash)	r_2 (abs. exch. rate)
non-Mexican ADRs & S&P 500 Augmented "Crash and Exchange Rate" Model	0.334(15.18)	0.117(4.365)	-0.075(-154.6)
L.A. Investment Fund & S&P 500 Augmented "Crash and Exchange Rate" Model	0.180(5.914)	0.169(3.381)	-0.012(-0.923)

Panel D Diagnostics

	non-Mex. ADRs	L.A. Fund	S&P 500
Loglikelihood	-656.795	-1501.250	
Autocorrelation in standardized residuals			
p-value: Ljung-Box Q(6), Q(12) - residuals	(0.283) (0.216)	(0.161) (0.090)	(0.223) (0.233)
p-value: Ljung-Box Q(6), Q(12) - squared residuals	(0.927) (0.973)	(0.199) (0.362)	(0.201) (0.381)
p-value: L-B Q(6), Q(12) - crossproduct with S&P 500	(0.100) (0.268)	(0.132) (0.091)	
Normality of standardized residuals			
p-value: Jarque-Bera (Normal) Statistic	0.000	0.000	0.000
p-value: skewness	0.003	0.000	0.000
p-value: kurtosis	0.000	0.000	0.000
Robust Wald tests			
p-value: constant variance in the equations	0.000	0.000	0.000
p-value: constant mean in the equations	0.000	0.001	0.000
p-value: significance of coefficients in covariance equation.	0.000	0.000	0.000

caused by the peso crash or if there was a significant shift in the integration between the two markets just around the time of the peso crash. Perhaps, the policies of market liberalization introduced several years earlier had now taken effect. This question is beyond the scope of the present paper but the issue of market integration is investigated elsewhere in this thesis. The result is that the markets are still only partially integrated.

Are New ADRs Responsible for the Pattern of Diversification? Here I attempt to explain why the non-Mexican ADRs provided diversification in the pre-crash period to the investor, when she holds the S&P 500 and the risk-free asset, but then failed to do so after the crash. Suppose that the Mexican economy underwent fundamental changes arising from the peso shock and that there were spillover effects to the region's other markets. The region's companies may have seemed even riskier as the economy appeared vulnerably exposed to exchange rate shocks and political instability, causing US investors to revise their expectations about investing in the region's ADRs after the crash. Bailey and Chung (1995) suggest that these risks are priced in the Mexican stock market.

A US investor might then take as a signal of fundamental weakness any new listing of ADRs after the crash. The investor would consider such action as an attempt on the part of the region's corporate managers to rid current (local) investors of a part of what management now knows is a riskier company by offering shares to foreign investors. Karolyi (1996) and others note that companies cross-list to broaden ownership, increase liquidity, and reduce the cost of capital (since on cross-listing the fall in the national beta is not offset by the accompanying increase in the international beta), among other objectives. The existence of asymmetry in the information between managers and shareholders and between local and foreign investors would intensify the strength of this signal. In view of this, investors would price new Latin American ADRs to reflect the signal and to obtain greater compensation for the perceived increased political and exchange rate risks. The pricing of existing ADRs would also be affected but possibly much less than that of the new listings. I call this proposition the signaling hypothesis.

Another related factor could have generated the results. Some evidence in the literature suggests that the (underlying) stocks of the emerging markets tend to experience abnormal returns in the period prior to listing an ADR and that the ADRs perform poorly in the immediate post-listing period (e.g., Serra (1997)). The fact that the ADRs failed to provide diversification after the crash might be due to such poor post-listing performance (post-listing hypothesis) of the ADRs that were listed after the crash, rather than a reflection of the pricing implications of a signal.

I, therefore, examine these hypotheses to clarify the results by separating the ADRs into two subsets. The first set consists of those ADRs listed before the crash and the second contains the ADRs listed after the crash[69]. If Latin American ADRs

[69] To reflect the idea that the restiveness in the rest of Latin America was primarily a reaction to the Mexican crisis and to obtain large enough samples on which to make inferences, I use the end of September 1994 to demarcate the pre- and post-crash periods for the non-Mexican ADRs (18 and 10 ADRs, respectively). This is only a rough means of separating the assets. However, most ADRs which were issued before the crash were issued after 1992, hence, could still be undergoing any post-listing underperformance that there is in the market. Since there were signs of exchange rate volatility and political instability in Mexico from as early as February 1994 (see Appendix E) the September cut-off point should capture the essence of the phenomenon under review.

experience poor post-listing performance, then this should be evident in the performance of the ADRs listed both before and after the crash. But the ADRs listed prior to the crash would suffer from this post-listing blight only within the year or so after listing and should not continue to be affected in the post-crash period.

Table 7.9 considers both hypotheses. The benchmark in the following analysis is the portfolio of the S&P 500 and the risk-free asset even though the table reports the results for the other portfolios. In columns 3 to 5 the results suggest that we can in part attribute the failure to find diversification from the non-Mexican ADRs in the post-crash period to those ADRs listed after the peso crisis. The portfolio comprised solely of non-Mexican ADRs listed prior to the crash provides diversification before the crash (p = 0.000; Column 3), but fails to do so after the crash (p = 0.200; Column 4). Bearing in mind the caveat in the previous footnote, this suggests that the post-listing hypothesis is rejected in the non-Mexican market. That is, these ADRs do not underperform in the period following listing. On the other hand, those non-Mexican ADRs listed after the crash failed to provide diversification (p = 0.109; Column 5). If there is no post-listing underperformance in the non-Mexican ADRs market, as suggested above, then this failure of new ADRs to provide diversification is related to the peso crash. That is we cannot reject the signaling hypothesis that investors in the ADRs considered new listings as a signal of bad times ahead. The poor results from the non-Mexican ADRs as a whole after the crash are due to the bearish performance of both the more established ADRs (those listed before the crash) and the newly listed ADRs .

Table 7.9 Are New non-Mexican ADRs Responsible for the Post-Crash Performance?

The estimated equation is similar to that described in previous tables. The *test asset* in **columns 1 to 4** is a portfolio of non-Mexican Latin American ADRs issued *prior* to the peso crash. In **column 5** the test asset is the portfolio of non-Mexican Latin American ADRs listed *after* the peso crash. The matrix of instruments include a constant, lagged returns on the S&P 500, lagged returns on the Mexican (peso) index, and the lagged changes in the daily peso/dollar exchange rate. When the European ADRs are in the spanning assets, the lagged change in the daily dollar/pound exchange rate is added to the instruments. *The table presents a test of a signaling hypothesis that the poor performance of the non-Mexican ADRs after the crash (when the investor's portfolio is comprised of the S&P 500 and the risk-free asset) can be attributed to those ADRs listed* after *the crash* versus *a test of a hypothesis that new ADRs experience poor performance after listing, hence, the poor post-crash performance is due to newly issued ADRs*. The test statistic [p-value] is the number of observations times the minimized objective value of the GMM, which is chi-square distributed with degrees of freedom based on (N-K)×K×L orthogonality conditions and (N-K)×(K-1) unknown parameters.

Results for:	Full Period	Excl. Crash	Pre-Crash Period	Post-Crash Period	
Time of Listing:	XMLADR issued *prior* to crash				Post-crash listed XMLADR
Spanning Assets	(1)	(2)	(3)	(4)	(5)
S&P 500 Test [p-Value](4)	16.895[0.002]	14.088[0.007]	26.011[0.000]	9.979[0.041]	11.818[0.019]
S&P 500, Risk-free Test [p-Value](7)	**7.851[0.346]**	**5.615[0.585]**	**24.216[0.000]**	**9.808[0.200]**	**11.757[0.109]**
S&P 500, EuroDR Test [p-Value](9)	12.611[0.181]	11.016[0.275]	6.962[0.641]	7.102[0.627]	8.700[0.465]

EuroDR are ADRs from France, Japan, and the UK. XMLADR are non-Mexican Latin American ADRs. GMM test statistic p-value in [brackets] and degrees of freedom in (brackets).

Robustness to the Choice of Spanning Assets. The use of the S&P 500 in this study facilitates comparison with other similar studies. However, its composition could have affected the results given that the latter is comprised of large firms. In view of this, I investigate the robustness of the results using the CRSP value-weighted index without dividends (VWIX), and the value-weighted (VWID) and equally-weighted (EWID) indices, both with dividends. The results in Table 7.10 suggest that they are a function of the spanning asset used in the tests. However, there are similarities in the results. For instance, when these new benchmarks are extended to include the risk-free asset and the EuroDR there are no gains from diversification and when the

VWIX, which is most closely related to the S&P 500, is the benchmark there are no significant gains from diversification in either sub-period.

Table 7.10 Is the Diversification from non-Mexican ADRs Robust to the Choice of US Index?

The *spanning assets* are US indices as listed in the table. The *test asset* is a portfolio of ADRs from the non-Mexican Latin American markets. The vector of instruments include a constant, lagged returns on the respective spanning asset, lagged returns on the Mexican (peso) index, and the lagged changes in the daily peso/dollar exchange rate. When the European ADRs are in the spanning assets, the lagged changes in the daily dollar/pound exchange rate is added to the instruments. *The table presents a test of whether or not the diversification provided by the non-Mexican ADRs in the pre-, but not the post-crash period, is robust to the choice of the US index.* The test statistic [p-value] is the number of observations times the minimized objective value of the GMM, which is chi-square distributed with degrees of freedom based on (N-K) × K× L orthogonality conditions and (N-K) × (K-1) unknown parameters.

Test Assets: Portfolio of ADRs from non-Mexican Latin American Markets

	VWIX VWID EWID (4)	VWIX & Risk-free Asset VWID & Risk-free Asset EWID & Risk-free Asset (7)	VWIX & European ADRs VWID & European ADRs EWID & European ADRs (9)
Full Period	14.197[0.007]	13.334[0.064]	13.107[0.158]
	15.043[0.005]	13.335[0.064]	13.687[0.134]
	15.059[0.005]	13.201[0.067]	14.247[0.114]
Excl. Crash	11.842[0.019]	10.981[0.139]	10.997[0.276]
	4.004[0.405]	3.935[0.787]	3.893[0.918]
	14.130[0.007]	7.740[0.356]	16.646[0.055]
Pre-Crash Period	3.756[0.440]	3.780[0.805]	3.339[0.949]
	8.400[0.078]	8.241[0.312]	9.334[0.407]
	8.816[0.066]	8.630[0.280]	6.258[0.714]
Post-Crash Period	8.430[0.077]	8.257[0.310]	9.349[0.406]
	12.791[0.012]	11.013[0.138]	11.580[0.238]
	13.242[0.010]	11.160[0.132]	11.927[0.217]

GMM test statistic, p-value in [brackets], and degrees of freedom in (brackets). European ADRs are from France, Japan, and the UK. Non-Mexican ADRs are from Argentina and Chile. VWI (EWI) are the CRSP value- (equally-) weighted index with capital distributions (D) and without (X).

V. Summary and Conclusions

I use daily data over the period 1992 to 1996 to show that the diversification provided for a US investor by the emerging markets is sensitive to economic and political events such as the Mexican peso crash of 1994, notwithstanding their characteristically higher average returns and low correlation with the developed markets. The latter attractive features of the emerging markets must be tempered by another common feature, extreme currency fluctuations. This study, therefore, has broadened the debate on the ability of the emerging markets to provide international portfolio diversification. Furthermore, while previous authors have found diversification benefits from emerging markets' country funds and indices, their ADRs have not been studied in this manner. Also, this study concentrates solely on the post-liberalization period for the emerging markets evaluated.

Main Findings. The main results of this study are from the conditional tests. First, the Latin American ADRs and country funds provide diversification in the period prior to the peso crash but not after. Second, as the investor expands her portfolio to include the risk-free asset, the strength of any diversification from either the ADRs or the country funds declines. Third, when the investor holds an internationally diversified portfolio of the S&P 500 and ADRs from the developed markets, all evidence of further diversification from the emerging markets disappears completely. Fourth, among the Latin American ADRs, only those from the non-Mexican markets provide diversification benefits for the US investor and only when she holds the domestic portfolios. Finally, these results seem not to be driven by an international factor affecting all ADRs and country funds simultaneously since the Asian ADRs provided diversification after the crash, while investing in the Asian fund would not have diversified the investor's portfolio in any period.

Some Implications. I find support for different explanations for the fact that in periods of high currency volatility there is a reduction in the diversification benefits from the emerging markets. One possible explanation is that US investors consider the listing of ADRs after a local crisis as a signal of poor expected future performance, given the shock to the local economy. This has implications for the timing of overseas listing of emerging market assets. There is an argument that firms list (domestic or otherwise) their shares after having had a series of successful results and that this might explain any subsequent relatively poor performance. Another argument is that the announcement and listing of shares on a prestigious foreign market signals to investors an expectation of good future performance. In light of my findings, a reasonable conclusion would be that management should time their foreign listings to coincide with more tranquil periods at home and perhaps a more bullish market in the host country. This action would send a signal of good future prospects. Failing that, the signal from listing during times of turbulence in the local market is one of poor future expectations in the local market. The relevance of this timing hypothesis is clear for the current crisis in Asia. That is, one lesson that can be learned from the Latin American crisis is that timing of foreign issues in relation to a local crisis is important.

That the conditional correlation between the non-Mexican ADRs and the S&P 500 increased by over a third and that between the regional country fund and the S&P 500 nearly doubled in the period following the crash is another possible explanation. However, it is not clear as to the cause of this increase in correlation at the time when Mexico, and to a lesser extent, the rest of the region was undergoing substantial uncertainty. One possibility might be that the earlier reforms in these markets and the listing of new ADRs were beginning to bear fruit, while another is that it is just a transitory phenomenon related to increased volatility rather than to integration.

Chapter 8. Are the Latin American Equities Markets Internationally Integrated?: New Evidence Using ADRs

This paper presents new evidence concerning the integration of the Latin American equities markets by employing an approach which overcomes the joint-hypothesis problem that arises in tests of integration using asset pricing models. Whether or not these emerging markets are integrated is yet to be resolved, and the extant literature is fraught with conflicting evidence (e.g., Bekaert and Harvey (1994), Bekaert (1995), Korajczyk (1995), and Levine and Zervos (1996)). Unlike past efforts at studying the integration of the emerging markets, the period under review is that following the major stock market liberalization in Latin America and that includes the economic integration of Mexico with North America under the North American Free-Trade Agreement (NAFTA (1994)). The paper also provides an insight into the classes of barriers to international portfolio investments that may still exist in these markets several years after embarking on a path towards market liberalization.

The importance of market integration cannot be overstated in finance. For instance, the cost of capital is country-specific in segmented markets, causing projects with perfectly-correlated cash flows to have different values across countries. Additionally, option pricing depends on the integration of the markets for the option, bond, and underlying asset. Furthermore, the CAPM which uses the domestic stock market as its sole risk factor is valid only in internationally segmented markets. Finally, only when the prices of risks across countries are the same (i.e., markets are internationally integrated) can the reward-to-risk ratio from investing in international markets be properly assessed and it is always optimal to diversify internationally.

There are major differences between the emerging and developed markets. Bekaert and Harvey (1995), for instance, note that the emerging markets are more predictable and have higher average risk and return, and that their risk display both time series and cross-sectional variation. These features may be reflecting the fact that they are only partially integrated with the international capital markets and are displaying time-varying integration (Bekaert and Harvey (1994)). The question of how to price assets from markets that might not be fully integrated with the international capital markets (see, e.g., Solnik (1974a), Black (1974), Stehle (1977), Stulz (1981b), Errunza and Losq (1985a), Eun and Janakiramanan (1986)) is important for international portfolio management.

The most generally accepted definition of integration is that markets are fully integrated if assets with perfectly correlated returns have the same price in a given currency regardless of the market within which they trade. Equivalently, if two assets have identical risks, then they should be priced to yield the same *expected* returns. If the above definitions hold, then a third follows immediately: if two markets are integrated, then the price of risk associated with each priced risk factor should be equal across markets; this condition should hold not only on average, but also in each period. Segmentation exists, therefore, if "...two assets...(which) have the same risk with respect to some model of international asset pricing without barriers to international investment have different expected...returns." (Stulz (1981a))[70]. The tests

[70] This definition of integration has been used by Naranjo and Protopapadakis (1996), Webb, Officer, and Boyd (1995), Bekaert and Harvey (1994), Harvey (1994a), Campbell and Hamao (1992), Bosner-Neal, Braur, Neal, and Wheatley (1990), Gultekin, Gultekin, and Penati (1989), Wheatley (1988), Jorion and Schwartz (1986), Errunza and Losq (1985a), and others. *Multi-factor* asset pricing models such as the APT have been used as a benchmark to measure risk across markets since asset returns may be related to a small number of numeraire-invariant common factors, hence, this specification holds without the assumptions of strict PPP (e.g., Grauer et al. (1976)), lognormal utility functions (Adler and

executed in this paper are based on the null hypothesis that the prices of risks for the region's American Depositary Receipts (ADRs) and for their underlying stocks are equal. They, therefore, rely on the strict definition of market integration. In fully integrated markets, ADRs and their underlying stocks are perfect substitutes (e.g., Alexander et al. (1987, 1988)), both based on the same cash flows and are exposed to the same systematic factors. Therefore, the Latin American markets are internationally integrated if the prices of risks are equivalent for these two sets of assets.

The paper proceeds in two steps. In the first step, I characterize the volatility of the portfolios of ADRs and their underlying stocks. Since Latin American ADRs are still fairly new to the literature, this is not only informative about this specific feature of the assets, but it also influences the tests of integration applied later in the paper. First, I check for predictable time variation in, and assess the persistence of, the volatility of the Latin American assets. Second, I investigate if a set of global instruments commonly used in the international asset pricing literature has incremental predictive power for the mean and volatility of Latin American assets. Third, I test if there is an asymmetric response in volatility to bad news in the equities market.

In the second step, the null hypothesis of integration of the Latin American markets is tested by assessing if there is a difference between the prices of world systematic risks for the region's ADRs and their underlying stocks. I extend the framework employed

Dumas (1983)), or zero correlation between exchange rate and stock returns (e.g., Solnik (1974b)), as required with *single-factor* measures of risk such as the international CAPM, (see Solnik (1983) for proof; see also Gultekin et al. (1989)).

by Jorion and Schwartz (1986) and Mittoo (1992)[71] in two important dimensions to investigate integration. First, unlike the latter authors, I use a conditional version of an international asset pricing model (ICAPM) in which the risk factors are the covariances between the returns on the Latin American assets and the returns on the world leading equities and currency markets. The model also allows for time-variation in the prices of these world risks. This specification has two important implications. In the first instance, the conditional tests are consistent with the theory of asset pricing models (e.g., Sharpe (1964), Lintner (1965), Black(1972), Merton (1973), etc.), even though most empirical tests are based on the unconditional implications of the models (see Jagannathan and Wang (1996)). In the second instance, evidence in Dumas and Solnik (1995) and De Santis and Gerard (1996b) suggests that currency risk is priced in the international equity markets but that the price of this risk is significant only if the model captures its variation over time. Furthermore, Harvey (1994a) finds that the conditional version of the ICAPM provides marginally better results than the unconditional model in explaining the dynamics of returns in the emerging markets.

The second and more important extension to the Jorion-Schwartz-Mittoo approach is the application of the tests to ADRs and their underlying stocks in a manner which overcomes the joint-hypothesis problem which arises if the null hypothesis of integration is rejected[72]. Most tests of integration are joint tests of the null hypotheses that markets are integrated and that the specific asset pricing model holds. Hence, if

[71] Harvey (1991) also makes inferences about integration by testing for the differences in the price of world market risk across several developed markets. Naranjo and Protopopodakis (1996) use a multi-factor asset pricing model to test the integration of the AMEX, NYSE, and NASDAQ.
[72] An alternative test of integration in Chen and Knez (1995) overcomes the joint-hypothesis problem and Fama (1991) notes that event-study type tests do well in this regard in tests of market efficiency.

the null hypothesis is rejected, then this could result from a rejection of integration, a rejection of the asset pricing model by the data, or both. However, by applying the asset pricing model to both the ADRs and their underlying stocks, the problem can be resolved. Let us suppose that the world risk factors are priced by the emerging markets but that the null hypothesis of equal prices of risks between the ADRs and their underlying stocks is rejected. Then it is necessary to separate a rejection of the null hypothesis arising from the failure of the model to accurately describe the data (even though the null hypothesis is true) from one that is due to the fact that the market is in indeed segmented. If the null hypothesis is rejected and the market is truly segmented, then the presence of a joint hypothesis poses no serious problem as we are correctly rejecting a false null hypothesis.

The task is to reduce the probability of rejecting the true null hypothesis (the type I error). In integrated markets, the ADRs and their underlying stocks are really one asset (based on the same underlying cash flows emanating from some common commercial activity) that is trading in two different markets. If these two markets are integrated, then the ADRs and their underlying stocks are of equal risk, hence, they yield the same expected returns. Additionally, they are priced by the same asset pricing model and generate the same price of risk for each priced risk factor. Hence, providing the markets are integrated there will be no difference in the prices of risks for these assets trading in the two markets, even if the same "incorrect" asset pricing model is applied to both sets of assets. It follows immediately, therefore, that from the above definition of integration any rejection of the null hypothesis of equal prices of risks between the ADRs and their underlying stocks means that the Latin American markets are not integrated. In other words, given the null hypothesis of equal risk prices and since the same asset pricing model is applied to both sets of assets, it is irrelevant that the specific model might have been rejected by the data. That is, even with the "wrong" model, if the market is integrated, then the ADRs and their underlying stocks must "reject" the model to the same extent. Failing, therefore, to detect equal prices of risks in the two markets for those factors that are priced leads us to conclude that the markets are not integrated.

Hence, the test as applied in this paper is a more powerful application than that in Jorion and Schwartz (1986) and Mittoo (1992). That is, in their test it may be that the Canadian market is integrated but that the cross-listed and purely-domestic (Canadian) stocks are priced by different asset pricing models. In this case a rejection of the null hypothesis of integration (i.e., of equal prices of risks) may be driven by the rejection of the model by the data. It is not possible, however, that the ADRs and their underlying stocks are separately priced by different asset pricing models if the market is integrated.

An additional advantage of the test of integration employed in this paper is that it allows us to make inferences about the types of barriers to international investments that cause segmentation that may still exist in these markets. For instance, indirect barriers such as lack of quality information about the emerging markets and poor accounting standards in the markets issuing the ADRs could be the cause of segmentation. On the other hand, there may be legal barriers such as capital and currency controls (see, e.g., Jorion and Schwartz (1986), Bekaert (1995)) which are binding for foreign investors transacting in the underlying stocks but which are surmounted by trading in the ADRs. Let us consider the world market as the benchmark of integrated markets. If the null hypothesis of equal prices of risks between the underlying stocks and the world market is rejected while the null hypothesis cannot be rejected for the ADRs, then the implication is that there exist indirect barriers in the Latin American markets. The existence of legal barriers, however, would lead to a rejection of the null hypothesis for both the ADRs and their underlying stocks.

Finally, the application of a direct test of integration which relies on the strict definition of integration, the choice of the post-liberalization period in the emerging markets, the use of ADRs and their underlying stocks to overcome the joint-hypothesis problem and to allow further inferences about the causes of segmentation, and the different econometric method employed in this paper provide a robustness test for the previous studies on the integration of the emerging markets.

The remainder of this paper contains five sections. Section I briefly reviews the tests of integration of the emerging markets. As is relevant, the related literature on volatility and the application of the ICAPM is also presented. Section II explains the methodology. Section III describes the data and the preliminary analyses. Section IV presents the results. The main findings are that both the market and currency risks are priced by the Latin American assets and that there is significant variation in these risk prices. There is strong evidence to suggest that the Latin American markets are only partially integrated with the world capital markets. The paper's summary and conclusions are in Section V.

I. Brief Literature Review

This section briefly outlines some of the papers that are relevant to the study of the integration of the emerging markets (for more details see Chapter 3, especially Table 3.1) and to the dynamics of their returns and volatility.

I. A. Tests of Integration

Stulz (1994) states that tests of market integration using asset pricing models typically lack power. It is no wonder then that there are mixed results since most tests of the integration of the emerging markets employ an asset pricing model. However, one advantage of using asset pricing models to test for integration is that asset prices are able to capture the impacts of effective barriers to international investments regardless of the type of barriers. Hence, if barriers such as limits on foreign ownership of firms are imposed but are not binding, then the asset prices will reflect the ineffectiveness of the barriers. However, an attempt to explicitly model the barrier may lead to misleading conclusions if they exist but are not effective.

Two general approaches to investigating market integration characterize the literature. The first applies an international asset pricing model which is consistent with the existence of full integration and then tests if the results are contrary to the expectations, given the assumption of full integration. For instance, Campbell and Hamao (1992) use the latent variable model, Jorion and Schwartz (1986), Harvey (1991), and Mittoo (1992) employ an international CAPM, Cho, Eun, and Senbet (1986) use the international APT (IAPT), and Wheatley (1988) applies a test based on the Consumption CAPM (CCAPM).

The second approach assumes complete segmentation, models the observed market-segmenting barriers, and incorporates their effects on equilibrium returns and portfolio holdings. The barriers are usually represented by taxes (e.g., Black (1974), Stulz (1981b)), by placing limits on the level of foreign ownership in a particular market (e.g., Hietala (1989), Eun and Janakiramanan (1986), Alford and Folks (1996)), or by other restrictions such as "outward" and "inward" costs of investing overseas (e.g., Cooper and Kaplanis (1994a)).

However, there are tests of integration which are not based on these structured asset-pricing models. Ammer and Mei (1996) use the correlations between the expected excess returns derived from the approximate present value model[73]; Chen and Knez (1995) use the pricing kernel to develop two measures of integration based, respectively, on the law of one price and on the absence of arbitrage between integrated markets; Sundaram and Logue (1996) use event-studies and Arshanapalli and Doukas (1993) tests for cointegration between a national market and the world market to make inferences about integration.

[73] But Adler and Dumas (1983) note that it is misguided to use correlation between markets to make inferences about integration.

Various methods have been used to test for integration of the emerging markets. For instance, Bekaert and Harvey (1994) apply a regime-switching model based on a one-factor asset pricing model which allows a market to move between segmentation and integration. Korajczyk (1995) develops a measure of the deviation from the law of one price (LOP) within the framework of the IAPT and Levine and Zervos (1996) use this model to examine if the emerging markets became more integrated following liberalization. Errunza and Losq (1985a) and Errunza, Losq, and Padmanabhan (1992) place limits on the degree of foreign ownership of emerging market stocks and categorize the degree of integration into full integration, complete segmentation, and "mild segmentation" in order to reflect the notion that markets are usually never fully integrated nor completely segmented. Bekaert (1995) uses the correlation between the conditional returns on the US and emerging markets, where the conditioning variables are a common set of global instruments. Bosner-Neal et al. (1990) test the impact of the announcement of market liberalization on the price/NAV (net asset value) ratio of emerging market country funds. Chang et al. (1995) employ cointegration to test for a long run equilibrium relation between the returns on emerging market country funds and their underlying assets and Bekaert and Urias (1995) use the difference between the stochastic discount factors of the country funds and their NAV to estimate the level of expected return that a foreign investor would be will to forego in order to have barrier-free access to the emerging markets.

I. B. The Dynamics of Emerging Market Returns

The expected returns on the stocks of emerging markets have been investigated by several authors using various specifications of the International CAPM. Harvey (1994a) applies conditional and unconditional asset pricing models to the indices of 20 emerging markets. When the excess returns on the world market portfolio represent the single factor in an (unconditional) Sharpe (1964)-Lintner (1965) model, the results are an overwhelming rejection of the CAPM. Only seven countries have significant betas while only Portugal has a world beta greater than one. There is an improvement in the performance of the model when augmented by the addition of a foreign-exchange risk factor with eight markets having significant exchange rate betas but only three with betas greater than one. Two other factors (a natural resources price index and an agricultural goods price index) provided no added explanatory power, nor did the three (commodity prices, world inflation, and world business cycle) in Harvey (1995). The pricing errors (intercepts) are significantly different from zero and economically large indicating that the world market portfolio is inefficient with respect to the emerging markets. (See Chen et al. (1986) for priced macro-economic factors).

Harvey (1994a) finds that despite the failure of the unconditional CAPM the returns on the emerging markets are predictable and that part of this predictability is derived from global instruments even though local variables explain most of the variation. He then applies a conditional asset pricing model where the expected returns, price of beta risk, and betas vary as a function of the information variables. The betas are significant for eight markets, about half the sample tested, when the one-factor model is used; however, the model still does not explain the returns on emerging markets very well. The two-factor (world market and currency index) model, though resulting in significant and time varying betas in six of the markets, cannot explain the variation in the expected excess returns as large and predictable pricing errors are observed for three of the markets, and the model performed poorly in relation to other diagnostics. The conclusion is that the degree of (and time-variation in) integration must be considered in order to successfully price emerging markets' assets (Bekaert and Harvey (1994)).

Bailey and Chung (1994) find that foreign exchange and political risks are priced in the Mexican stock market. They find that various portfolios of Mexican stocks load significantly onto the proxies for political and exchange rate risks and that there is evidence of predictability of the portfolios' excess returns when conditioned on a set of local information variables. The ability of the information variables to predict the portfolio returns suggests that they might be able to detect time-varying risk premia in these returns. However, the null hypothesis of constant betas could not be rejected. Factor-mimicking portfolios were then estimated using the Fama-McBeth (1973) method. These had means not significantly different from zero; i.e., no unconditional risk premia. However, when the mimicking portfolios are regressed on the instruments, the null hypothesis of constant price of risk is rejected for three of the four factors representing political and currency risks. The results did not change when an alternative specification is employed to overcome the errors-in-variables problems associated with the two-pass approach.

De Santis and Imrohoroglu (1996) and Susmel (1997b) also consider the ICAPM for the emerging markets. The former includes a lagged return to capture the autocorrelation in the data and used raw returns instead of excess return, i.e., a version of the Black (1972) model. There is little support for the model assuming complete segmentation of the emerging markets, except in the cases of Argentina, The Philippines, and Venezuela. Tests of regional and global integration indicated that in the Asian markets neither the regional nor the global market risk is priced. However, the Latin American markets provided compensation for exposure to both a regional and a global index. Tests of whether country-specific risk is rewarded prior to and global risk after liberalization support the earlier result that country-specific risk is not priced and suggested that global risk is also not priced. There is limited evidence that the liberalization of emerging markets did not result in increased volatility. Susmel focuses on four Latin American indices and finds marginal support for a world factor for Brazil and Mexico in a one-factor model. When he uses the Mexican index to proxy for a Latin American factor he finds significant betas in all three markets. The same is observed when an unobserved factor is extracted from the returns of the four markets.

I. C. Emerging Market Volatility

The most comprehensive study of the volatility of the emerging markets is contained in Bekaert and Harvey (1995). In their paper they explore three main issues. First, to what extent is the time series of emerging market volatility predictable given the evidence of higher predictability of the returns on emerging markets in Bekaert and

Harvey (1994), Bekaert (1995), and Harvey (1994a). Second, they assess the success of several national and global information variables in predicting volatility, consistent with the evidence in developed markets (e.g., Schwert (1989)). Finally, they shed light on the differences in volatility across the emerging markets by investigating the ability of several features of the emerging markets, such as the number of stocks listed and the concentration (proportion of market value accounted for by the largest stocks) of the market, to explain the cross section of volatility. They also accounted for time-varying integration especially as it relates to market liberalization. The main results are that the time series properties of emerging market volatility are predictable and are best captured by including fat-tail, skewness, and asymmetric features but that improved specifications can be obtained by including global explanatory variables. There is evidence that the impact of world factors on volatility changes with time. In the pre-liberalization period the impact is minimal but this increases after liberalization. The difference in volatility across various emerging markets is influenced significantly by various microstructural factors, proxies for market integration and macroeconomic variables, and political risk. There is support for the claim that stock market liberalization results in the reduction of stock market volatility.

Susmel (1997b) applies a Switching ARCH (SWARCH) model to the indices of several Latin American markets. This model better accounts for any low-frequency structural breaks in the volatility of the series, e.g., the December 1994 peso crash in Mexico, and reduces the magnifying effect of outliers on the forecast of volatility. He finds that the Latin American markets underwent two volatility regimes in the period

1989 to 1996, that the volatility in the high state is about four times larger than in the low state with a possible third state of a few exceptionally large spikes in volatility, that the previously noted asymmetry in volatility disappeared, and that except for the period surrounding the peso crash there is no common volatility states across Latin America. De Santis and Imrohoroglu (1996) find highly predictable volatility in the emerging markets with strong ARCH and GARCH effects. This is in contrast to Susmel who finds that the portion of volatility induced by pricing errors (ARCH effects) turns out to be insignificant.

The impact of the listing of ADRs on the risk of emerging markets is investigated by Urias (1996). This is an extension of the tests of the impact of market liberalization on stock market risk with the difference being that the focus is on the "liberalization" of individual stocks (by the listing of ADRs). Specifically, he models the effect of interlisting on the exposure to US and local factors for both the firms listing the ADRs and for the purely domestic firms. In Argentina and Chile the issuing of ADRs led to a statistically insignificant increase in the exposure to the US factor and a decline in the responsiveness to the local factor by the ADR firms. The reverse is observed in the case of Venezuela. The hypothesis that a market's first ADR (and all other ADRs listed prior to a stock's own listing of an ADR) did not increase the US risk exposure of a new ADR cannot be rejected except in some cases in Venezuela where the direction (sign) of the impact is mixed. For the purely-domestic firms (except in the case of Argentina) the first ADR and the group of ADRs listed subsequently did not result in a decrease in exposure to the local factor and an increase in exposure to the US. This suggests a lack of support for the "externality effect" stated by Alexander, Eun, and Janakiramanan (1987) whereby interlisted stocks aid in the integration of the entire market and more so of the domestic stocks most correlated with the ADRs.

II. Methodology

II. A. Emerging Market Volatility

The ARCH model introduced by Engle (1982) and generalized by Bollerslev (1986) reflects well some of the peculiarities of speculative asset prices. Its widespread use in finance indicates the success with which the model has been applied (see Bollerslev, Chou, and Kroner (1992)). For instance, the "volatility clustering" (noted, e.g., in Fama (1965)) is captured by the conditional heteroscedasticity of the ARCH models. Various specifications of the model are employed in this paper to reflect the time-variation in the expected returns and integration of the emerging markets.

The first step in the analysis uses a simple GARCH(1,1) model to assess the incremental predictability of exogenous variables in the mean and variance by specifying the following model:

$$R_t = \mathbf{Z}'_{t-1}\Gamma + \varepsilon_t \qquad \text{where} \quad \varepsilon_t = \sqrt{h_t}\,\eta_t$$

$$h_t = \omega + \alpha\varepsilon^2_{t-1} + \beta h_{t-1} + \mathbf{Z}'_{t-1}\Lambda\,. \tag{8.1}$$

R_t is the return on the portfolio of assets, h_t is the conditional variance, $\eta_t \sim$ N(0,1), are residuals standardized by dividing the residuals, ε_t, by the standard deviation, $\sqrt{h_t}$, and let Ω_{t-1} be the information set at time t-1. $\mathbf{Z}$ is a $k\times1$ vector of instrumental variables that predict the conditional mean and volatility, and Γ and Λ are $k\times1$ vectors of coefficients. The orders of the lags in the conditional variance can be obtained from an ARMA respecification (e.g., Bollerslev (1989)), but Bollerslev et al. (1992) note that the GARCH (1,1) is usually a suitable specification in most empirical work. Several papers on emerging markets cited above find that restriction suitable and it is employed here. The selection of the instrumental variables is influenced both by the literature on volatility (e.g., Schwert (1989)) and on the predictability of equity markets (e.g., Keim and Stambaugh (1986), Harvey (1991), Bekaert and Hodrick (1992), Ferson and Harvey (1993), Haugen and Baker (1996); Hawawini and Keim (1995) review the literature on predictability)[74]. Persistence of the volatility shocks can be gauged by the size of $\rho = \alpha + \beta$ in (8.1) modified by dropping the exogenous variables in the conditional variance. The half-life τ of the shock is estimated from solving $(\rho)^{(252/52)\tau} = 0.5$ (Taylor (1994)).

It is well known that there is asymmetry in the volatility of equity markets. That is, volatility increases more when markets fall than when they rise. Intuitively, if (highly-) leveraged firms experience negative returns, then their leverage is increased which then causes greater volatility (e.g., Braun et al. (1995)). In the context of this paper, if the markets are segmented, and the marginal investor in the ADRs interprets news differently from the investor in the local underlying stocks, then these clienteles may react differently to bad news thus causing a difference in the asymmetry in the volatility of the two sets of assets in reaction to the same news. If volatility is increased when market returns are negative, then the GJR-GARCH model captures

[74] Predictability of returns is not necessarily inconsistent with market efficiency (Fama (1976, p.149)).

this asymmetry. Engle and Ng (1993) find that this specification performs better than others such as the Exponential GARCH model (of Nelson 1991)). By modifying the 0conditional variance in equation (8.1) we obtain:

$$h_t = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1} + \delta S_t \varepsilon_{t-1}^2 , \tag{8.2}$$

where S is an indicator dummy: $S_t = \begin{Bmatrix} 1, \text{ if } \varepsilon_{t-1} < 0 \\ 0, \text{ if } \varepsilon_{t-1} \geq 0 \end{Bmatrix}$. δ is positive if there is asymmetry in the volatility.

II. B. The Solnik-Sercu[75] ICAPM

The use of the domestic market portfolio in the CAPM to price home-country stocks implicitly assumes that markets are internationally segmented. To reflect the notion that markets are integrated, several papers specify an international version which uses the world market portfolio as the sole risk factor. This model, however, is highly restrictive and holds only under several assumptions[76]. If the assumption of strict purchasing power parity (PPP) is violated, e.g., then exchange rate risk is priced in addition to the market risk. This gives rise to the Solnik-Sercu version of the ICAPM.

[75] The Solnik (1974b)-Sercu (1980) model is also referred to as the Adler-Dumas (1983) model.

[76] This single index international (*world*) CAPM holds only under the assumption of strict purchasing power parity (e.g., Grauer, Litzenberger, and Stehle (1976)), logarithmic utility functions (Adler and Dumas, (1983)), or zero correlation between exchange rate and stock returns (e.g., Solnik (1974b)).

To reflect the specific circumstances and interests of this study, I specify a modified version of the Solnik-Sercu asset pricing model[77]:

$$E(r_{it} \mid \Omega_{t-1}) = \varphi_{t-1} \operatorname{cov}(r_{it}, r_{mt} \mid \Omega_{t-1}) + \kappa_{t-1} \operatorname{cov}(r_{it}, f_t \mid \Omega_{t-1}) \quad \forall i, \tag{8.3}$$

where r_{it} is the nominal return on asset or portfolio i, in excess of the rate on a risk-free asset from the country in whose currency the returns are measured, r_{mt} is the excess return on the world market, Ω_{t-1} is the information set at t-1 that investors use in making their investment decisions. The time-varying coefficient φ_{t-1} is the world price of market risk. It is interpretable as the wealth-weighted average relative risk aversion (of all investors in all countries). f_t is the log first difference of a trade-weighted index of exchange rates against the dollar for the ten largest industrialized countries (except the US). κ_{t-1} is the time-varying world price of exchange rate risk. By using the trade-weighted index of exchange rates this specification differs from the Solnik-Sercu model and is not strictly consistent with asset pricing theory. However, this factor has been used by Ferson and Harvey (1993, 1994), Bailey and Jagtiani (1994), and Harvey, Solnik, and Zhou (1994) to achieve tractability. An alternative approach is to use the rate of return on Eurocurrency deposits (e.g., Dumas and Solnik (1995) and De Santis and Gerard (1996b)).

The asset pricing model does not specify how the conditional second moments should be modeled. Several papers have tested asset pricing models using conditional

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[77] For a fuller account of the model see Adler and Dumas (1983), Dumas and Solnik (1995), and De Santis and Gerard (1996b). Harvey (1995) expounds on the model and outlines the construction of an alternative index to the one used in this paper.

expected returns, covariance, and variance in a multivariate GARCH framework (e.g., Bollerslev, Engle, and Wooldridge (1988), Bodhurta and Mark (1991), Ng (1991), Chan, Karolyi, and Stulz (1992), De Santis and Gerard (1996a, b)). De Santis and Imrohoroglu (1996) apply this model to the emerging markets. Others have tested the conditional model using the GMM (e.g., Harvey (1991)).

To estimate the model, let the data vector $\mathbf{r}_t$ contain realized excess returns on the portfolio of ADRs, the underlying stocks, and the world market, and the log first difference of the exchange rate index (in that order) and let $\mathbf{H}_t$ be their variance-covariance matrix. The following four-equation system is then estimated:

$$\mathbf{r}_t = \varphi_{t-1}\mathbf{h}_{m,t} + \kappa_{t-1}\mathbf{h}_{f,t} + \mathbf{e}_t, \quad \mathbf{e}_t | \Omega_{t-1} \sim N(0, \mathbf{H}_t) \tag{8.4}$$

where $\mathbf{h}_{m,t}$ is the third column of the 4×4 variance-covariance matrix $\mathbf{H}_t$ (the column containing the covariances with the world market portfolio), and $\mathbf{h}_{f,t}$ is the fourth column of $\mathbf{H}_t$ (containing the covariances with the world exchange rate index), $\mathbf{e}_t = (\varepsilon_{ADR,t}, \varepsilon_{UDR,t}, \varepsilon_{WLD,t}, \varepsilon_{TWIFX,t})'$ is a vector of innovations. Time-variation in the price of market risk is imposed in the following manner:

$$\varphi_{t-1} = (\mathbf{Z}'_{t-1}\Pi), \tag{8.5}$$

where $\mathbf{Z}$ is the vector of instruments and Π is a vector of coefficients.

Consistent with theory, I imposed a non-negativity restriction on the price of market risk in the case when the price of risk is constant ($\varphi = \exp(\varphi^*)$) and also when it is time-varying ($\varphi_{t-1} = \exp(\mathbf{Z}'_{t-1}\Pi)$). This restriction has been used by researchers such as Bekaert and Harvey (1995), De Santis and Gerard (1996a, b), although Ng (1991) and Bodhurta and Mark (1991) and others have assumed a linear relation. The time-variation in the price of currency risk is similarly captured by $\kappa_{t-1} = (\mathbf{Z}'_{t-1}\Theta)$ but no positivity restriction is imposed[78].

The variance-covariance matrix is parameterized using the *diagonal BEKK* model[79] and a GARCH (1,1) restriction (Engle and Kroner (1993)):

$$\mathbf{H}_t = \mathbf{C}'\mathbf{C} + \mathbf{A}'_1\mathbf{e}_{t-1}\mathbf{e}'_{t-1}\mathbf{A}_1 + \mathbf{B}'_1\mathbf{H}_{t-1}\mathbf{B}_1 \tag{8.6}$$

where **C** is a 4×4 upper-triangle matrix of constants, hence, positive definiteness of $\mathbf{H}_t$ is guaranteed. The matrices $\mathbf{A}_1$, $\mathbf{B}_1$ are diagonal matrices.

The model is estimated by maximizing the sample log likelihood for each period *t*:

[78] An alternative specification gave good results in the case of the constant prices of risks but became unwieldy in the case of the time-varying models. If the excess return on the market is negative then the price of risk could become negative. This can be accounted for by using the following specification: $\varphi_{t-1} = (\pi_i^U U + \pi_i^D (1-U))\mathbf{Z}_{t-1}$ where U = 1 if (R_{mt}-R_{ft}) > 0 and 0 otherwise, and π_1^U and π_1^D are the price of market risk when the risk premium is positive and negative, respectively. This specification of the price of market risk is very "general" in the sense that it allows for time-variation arising from changes in the information (state) variables and also from the price of risk varying across "good" and "bad" periods in the equities market. Pettengill, Sundaram, and Mathur (1995) use a similar specification to estimate the relation between excess return and beta.

[79] De Santis and Gerard (1996a) propose an even more parsimonious representation of the multivariate GARCH based on obtaining the (irrelevant) constants in the matrix **C** from the estimates of the ARCH and GARCH coefficients. That specification avoids estimation of the parameters in the **C** matrix, thus larger asset sets can be estimated using the multivariate GARCH.

$$L_t(\Phi) = -\tfrac{1}{2}\log\left|\mathbf{H}_t(\Phi)\right| - \tfrac{1}{2}\varepsilon_t'(\Phi)\mathbf{H}_t^{-1}(\Phi)\varepsilon_t(\Phi) \tag{8.7}$$

and over the sample period

$$L(\Phi) = \sum_{t=1}^{T} L_t(\Phi) \tag{8.8}$$

where Φ is the vector of parameters. I use the Broyden, Fletcher, Goldfarb, and Shanno (BFGS) algorithm instead of the popular Berndt, Hall, Hall, and Hausman (BHHH) (1974)) algorithm. Stability of the system was vigorously pursued to ensure global maximization. The coefficients are quasi-maximum likelihood (QML) estimates with a variance-covariance matrix robust to non-normality and is asymptotically equivalent to Bollerslev and Wooldridge (1992). That is, since financial variables are usually not normally distributed, an adjustment is made to the standard errors obtained from maximizing the Gaussian loglikelihood function. The QML estimators are consistent and asymptotically normal under certain regularity conditions with variance-covariance matrix equal to $\mathbf{D}^{-1}\mathbf{S}\mathbf{D}^{-1}$, where $\mathbf{D}$ is the negative of the expectation of the Hessian and $\mathbf{S}$ is the expectation of the cross-product of scores. The final model was selected based on the reasonableness of the coefficients, the diagnostics, and an inspection of the conditional variances and the covariances with the risk factors. The multivariate Schwartz Bayesian criterion was the final arbiter in the case where models performed similarly on the above criteria.

III. Data and Preliminary Analyses

This study uses weekly returns on a value-weighted index constructed from over 60 ADRs from Argentina, Chile, and Mexico (LATADR) during the period January 1992 to December 1996, for a total of 250 observations. All ADRs with at least one year of trading are included (see Appendix C). This period follows major attempts at market liberalization by the Latin American authorities and corresponds with the most active period of trading of the region's ADRs. All data for the ADRs are obtained from the Center for Research in Securities Prices (CRSP) database. A matching value-weighted index of the underlying stocks of the ADRs is also constructed (LATUDR). Several Latin American stocks, particularly from Mexico, have different classes of shares (see, e.g., Domowitz, Glen, and Madhaven (1996)). As each class has the same generic name, care is required in matching the ADR with its underlying stock when forming the underlying portfolio. In a few cases where this could not be done, the ADR is dropped from the index. The market portfolio is represented by weekly returns on the value-weighted FT-Actuaries world market index (FTWRLD). Data for the LATUDR and FTWRLD are obtained from Datastream International. The currency factor (TWIFXR) is the weekly log-price difference of a trade-weighted index of the US-dollar prices of the currencies of the ten largest economies except for the US. This index is used by Ferson and Harvey (1993) and Harvey, Solnik, and Zhou (1994) and is described by Harvey (1995). The data is obtained from the Chicago Federal Reserve Board.

All returns are log-price differences. The returns in the week of December 23, 1994 corresponding to the onset of the Mexican peso crash seem to be of a different magnitude and distribution than the rest of the data and was deleted. In the ICAPM I use the returns on the ADRs (XLATADR), the underlying stocks (XLATUDR), and the world index (XFTWRLD) in excess of the risk-free rate. The risk-free asset is represented by the seven-day return on the weekly issue of the one-month Eurodollar deposit in London. The selection of the international information variables is influenced by the international asset pricing literature. These include CONSTANT which captures the lack of time-variation (constancy) of the prices of risk. The lagged excess return on the world portfolio XFTWRLD should reflect broad changes in world equity markets which could impact on the Latin American markets. TERM is the spread between the 10-year US Treasury Note and the US 90-day Treasury Bill. This instrument is designed to capture the slope of the term structure; i.e., it is the term premium. DEFALT is the spread between the yields on Moody's Baa- and Aaa-rated corporate bonds, designed to impound the default premium. EUR01 is the one-month Eurodollar deposit rate and represents the short-term interest rate faced by firms. The interest-rate related information variables are not lagged and are calculated at weekly intervals.

In the tests of partial integration, regional instruments are represented by the weekly returns on the IFC Latin American Index (IFCLAR) and the weekly log-price difference of the Mexican peso/dollar exchange rate (MEXFXR). The data for these variables are obtained from Datastream International.

Table 8.1 presents primary statistics on the Latin American ADRs and their underlying stocks, the world market portfolio, and the trade-weighted index of exchange rates. Except for the world portfolio, the variables are highly skewed with excess kurtosis leading to non-normality, as supported by the Jarque-Bera statistics. There is first-order autocorrelation in the returns on the underlying stocks and the Ljung-Box statistic indicates that there may be higher-order autocorrelation in the underlying stocks and in the world portfolio. The cross-correlation between the variables (in levels and squares) are also displayed. The expected high correlation between the ADRs and their underlying stocks is observed. The correlation between the squared series is smaller in magnitude.

Table 8.2 summarizes the information variables. Except for a few correlations involving the TERM variable, the contemporary correlations are small, suggesting that each instrument makes an independent contribution to the information set.

Table 8.3 regresses each of the series on the common information set. All series are predicted (at the 10% level) by at least one instrument, while overall the null hypothesis of constant means is marginally rejected for the Latin American assets.

Table 8.1 Summary Statistics of Various Indices (Weekly)

ASSET	MEAN (%) (t-value)	STD DEV.	SKEWNESS (p-value)	KURTOSIS (p-value)	J-B Statistic (p-value)
XLATADR	-0.188 (-0.756)	3.933	-0.561 (0.000)	1.475 (0.000)	34.68 (0.000)
XLATUDR	-0.069 (-0.323)	3.356	-0.471 (0.003)	1.264 (0.000)	25.07 (0.000)
XFTWRLD	0.072 (0.882)	1.295	-0.310 (0.047)	0.105 (0.738)	4.046 (0.132)
TWIFXR	0.020 (0.261)	1.202	0.479 (0.002)	1.436 (0.000)	30.03 (0.000)

Autocorrelations

	XLATADR	XLATUDR	XFTWRLD	TWIFXR	XLATADR (squared)	XLATUDR (squared)	XFTWRLD (squared)	TWIFXR (squared)
$\rho(1)$	0.086	0.178	-0.035	-0.055	0.036	-0.037	-0.006	0.112
$\rho(2)$	0.117	0.118	-0.062	-0.054	0.217	0.176	0.028	0.192
$\rho(3)$	0.060	0.073	0.106	0.021	0.026	0.097	0.044	0.220
Q(4)	7.441	19.10	5.186	6.322	14.18	20.61	6.749	26.14
	(0.114)	(0.001)	(0.269)	(0.176)	(0.007)	(0.000)	(0.150)	(0.000)
Q(8)	7.738	22.17	6.708	10.92	28.35	42.44	9.136	33.89
	(0.459)	(0.005)	(0.568)	(0.206)	(0.000)	(0.000)	(0.331)	(0.000)
Q(12)	11.984	27.07	24.16	17.77	35.34	48.27	12.60	44.76
	(0.447)	(0.008)	(0.019)	(0.123)	(0.000)	(0.000)	(0.399)	(0.000)

Cross-correlations of Returns

Lag	-2	-1	0	1	2	Q(1 to 2)	Q(-2 to -1)	Q(-2 to 2)
XFTWRLD and XLATADR	-0.084	0.032	0.295	-0.037	0.071	1.616	2.073	25.65
						(0.446)	(0.355)	(0.000)
XFTWRLD and XLATUDR	-0.027	0.044	0.305	-0.036	0.070	1.584	0.663	25.67
						(0.453)	(0.718)	(0.000)
XFTWRLD and TWIFXR	0.093	-0.029	-0.340	0.080	-0.043	2.068	2.386	33.61
						(0.356)	(0.303)	(0.000)
XLATUDR and XLATADR	0.106	0.118	0.907	0.187	0.123	12.65	6.371	226.4
						(0.002)	(0.041)	(0.000)
XLATADR and TWIFXR	0.102	0.146	0.075	0.100	-0.004	2.544	8.043	12.01
						(0.280)	(0.018)	(0.035)
XLATUDR and TWIFXR	0.044	0.156	0.068	0.115	-0.030	3.598	6.611	11.39
						(0.165)	(0.037)	(0.044)

Cross-correlations of Squared Returns

Lag	-2	-1	0	1	2	Q(1 to 2)	Q(-2 to -1)	Q(-2 to 2)
XFTWRLD and XLATADR	-0.022	-0.004	0.143	0.009	-0.006	0.031	0.132	5.328
						(0.985)	(0.936)	(0.377)
XFTWRLD and XLATUDR	0.010	-0.080	0.177	-0.001	-0.043	0.465	1.600	9.946
						(0.793)	(0.449)	(0.077)
XFTWRLD and TWIFXR	-0.019	0.029	0.274	-0.001	0.033	0.283	0.304	19.48
						(0.868)	(0.859)	(0.002)
XLATUDR and XLATADR	0.160	0.019	0.883	-0.011	0.240	14.66	6.632	217.8
						(0.001)	(0.036)	(0.000)
XLATADR and TWIFXR	-0.054	0.018	-0.005	-0.006	-0.014	0.059	0.808	0.873
						(0.971)	(0.668)	(0.972)
XLATUDR and TWIFXR	-0.072	-0.031	0.019	-0.027	-0.046	0.723	1.557	2.373
						(0.697)	(0.459)	(0.795)

XLATADR, XLATUDR, XFTWRLD are the excess returns on the Latin American ADRs, the Latin American underlying stocks, and the FT-Actuaries world index. TWIFXR is the log-price differences of a trade-weighted index of the exchange rates of the top ten economies with the US dollar. Q(x to y) and J-B are the Ljung-Box Q statistic between lags x and y and the Jarque-Bera normality test, respectively.

Table 8.2 Summary Statistics of the Information Variables (Weekly)

Information Variables

VARIABLE	MEAN	STD DEV.	MINIMUM	MAXIMUM
XFTWRLD{1}	0.070	1.300	-4.214	3.369
TERM	2.342	1.006	0.550	3.900
EURO1	4.418	1.114	2.938	6.313
DEFALT	0.700	0.090	0.090	0.960
MEXFXR{1}	0.241	1.868	-7.179	17.72
IFCLAR{1}	0.183	3.352	-15.19	10.54

Autocorrelations

	XFTWRLD{1}	TERM	EUR01	DEFALT	MEXFXR{1}	IFCLAR{1}
$\rho(1)$	-0.0362649	0.992	0.987	0.959	0.047	0.121
$\rho(2)$	-0.0641297	0.982	0.983	0.905	0.154	0.099
$\rho(3)$	0.1178419	0.971	0.979	0.847	-0.005	0.154
Q(4)	6.094 (0.192)	966.5 (0.000)	975.6 (0.000)	776.9 (0.000)	23.96 (0.000)	20.97 (0.000)
Q(8)	7.092 (0.527)	1850 (0.000)	1923 (0.000)	1179 (0.000)	32.33 (0.000)	26.20 (0.001)
Q(12)	21.15 (0.048)	2654 (0.000)	2833 (0.000)	1381 (0.000)	47.29 (0.000)	34.97 (0.000)

Contemporary Cross Correlations of Returns

	TERM	EUR01	DEFALT	MEXFXR{1}	IFCLAR{1}
XFTWRLD{1}	-0.083	-0.015	-0.113	-0.063	0.283
TERM	1	-0.815	0.609	-0.078	0.000
EUR01		1	-0.500	0.108	-0.089
DEFALT			1	-0.086	0.128
MEXFXR{1}				1	-0.170
IFCLAR{1}					1

TERM, EUR01, and DEFALT are the US term premium, the weekly one-month Eurodollar deposit rate, and the US default premium. The term premium is measured by the difference between the yield on the 10-year Treasury Notes and the 90-day Treasury Bill. The default premium is the spread between the yield on the Moody's Baa- and Aaa-rated bonds. MEXFXR is the log-price difference of the Mexican peso/dollar exchange rate, and IFCLAR is the return on the IFC Latin American regional index.

Table 8.3 Tests of Predictability of the Instruments

The equations are: $R_{i,t} = b_0 + b_1 XFTWRLD_{t-1} + b_2 EUR01_t + b_3 TERM_t + b_4 DEFALT_t + b_5 IFCLAR_{t-1} + b_6 MEXFXR_{t-1} + e_{i,t}$. R_i are XLATADR, XLATUDR, XFTWRLD which are the excess returns on the Latin American ADRs, the Latin American underlying stocks, the FT-Actuaries world index, and TWIFXR is the log-price differences of a trade-weighted index of the exchange rates of the top ten economies with the US dollar. EUR01, TERM, and DEFALT are the weekly one-month Eurodollar deposit rate, the US term premium, and the US default premium. The term premium is measured by the difference between the yield on the 10-year Treasury Notes and the 90-day Treasury Bill. The default premium is the spread between the yield on the Moody's Baa- and Aaa-rated bonds. MEXFXR is the log-price differences of the Mexican peso/dollar exchange rate, and IFCLAR is the return on the IFC Latin American regional index. All estimates are based on Ordinary Least Squares with heteroscedasticity-consistent standard errors. *t*-statistics are in parentheses.

	XLATADR	XLATUDR	XFTWRLD	TWIFXR
(Global Instruments)				
Constant	0.074 (0.025)	-0.340 (-0.142)	2.585 (2.394)	-0.153 (-0.135)
XFTWRLD{1}	0.168 (0.834)	0.168 (1.103)	-0.071 (-1.116)	-0.030 (-0.460)
EUR01	-0.698 (-1.937)	-0.582 (-1.898)	-0.235 (-1.912)	-0.118 (-1.073)
TERM	-1.060 (-2.318)	-0.872 (-2.374)	-0.229 (-1.518)	-0.206 (-1.747)
DEFALT	7.585 (2.386)	6.998 (2.666)	-1.313 (-1.172)	1.678 (1.391)
(Regional Instruments)				
IFCLAR{1}	0.063 (0.702)	0.067 (0.851)	-0.005 (-0.234)	0.021 (0.904)
MEXFXR{1}	0.134 (1.110)	0.066 (0.506)	-0.040 (-1.021)	-0.028 (-0.908)
Adjusted R^2	0.0229	0.0267	0.0026	0.0001
Durbin -Watson Statistic	1.9024	1.7574	2.0190	2.2007
H_0: Zero Predictability of	12.040	11.169	5.889	7.728
Instruments - χ^2 (6) (*p*-value)	(0.061)	(0.083)	(0.308)	(0.259)

IV. Main Results

IV. A. Volatility of the Latin American Assets

The estimates of the volatility of the weekly returns on the Latin American assets are in Table 8.4. From Panel A it is noticeable that the world portfolio has insignificant ARCH effects ($\alpha = 0.022$, $t = 1.498$) unlike the ADRs and the underlying stocks. All assets display significant GARCH effects. Using the estimate discussed earlier, it seems that the weekly returns have less volatility persistence (0.90, 0.873, and 0.958) and, hence, half-lives (1.358, 1.053 and 3.333 weeks), than that usually noticed in daily data. Panel B reports several diagnostics which support the selected model.

Table 8.5 reports the results of GARCH tests of the predictability of the global instruments on the mean and volatility of the Latin American assets. Similar to the least squares regression results in Table 8.3, the instruments predict the means.
This is influenced primarily by the interest-rate related instruments as is observed from their individually significant coefficients in Panel A and the joint test in Panel C.

The information variables have little impact on the conditional volatility of the markets (except for the world portfolio which is driven by the lagged world market return). Hence, I do not model the instruments in the variance in the remainder of the paper. A cursory examination of the results indicates that the global instruments have a greater impact on the ADRs than on their underlying stocks. Any differential impact of the international variables would imply some degree of market segmentation.

Table 8.4 GARCH Estimates of the Volatility of the Various Assets

The most general mean equation is: $R_{i,t} = b_0 + b_1 R_{i,t-1} + e_{i,t}$. The conditional variance is: $h_{i,t} = c + \alpha (e^2_{i,t-1}) + \beta h_{i,t-1}$. $R_{i,t}$ is the LATADR, LATUDR, or the FTWRLD which are the returns on the Latin American ADRs, the Latin American underlying stocks, and the FT-Actuaries world index. Coefficients and their robust *t*-statistics (in brackets) are reported in Panel A. The standard errors are estimated using quasi-maximum likelihood.

Panel A Conditional Mean and Variance

	b_0	b_1	c	α	β
LATADR	0.038 (0.161)	--	1.435 (4.104)	0.117 (2.438)	0.783 (45.17)
LATUDR	0.104 (0.629)	0.189 (3.009)	1.366 (2.969)	0.166 (2.818)	0.707 (11.28)
FTWRLD	0.166 (2.042)	--	0.067 (0.928)	0.022 (1.498)	0.936 (18.90)

Panel B Diagnostics of Standardized Residuals

	LATADR	LATUDR	FTWRLD
Loglikelihood	-443.137	-402.438	-184.751
Autocorrelation			
Q(4) - Levels[a]	5.852 (0.211)	4.819 (0.306)	5.344 (0.254)
Q(8)	7.717 (0.462)	11.90 (0.156)	6.167 (0.629)
Q(4) - Squares[b]	0.744 (0.946)	2.766 (0.598)	4.072 (0.396)
Q(8)	6.743 (0.565)	9.175 (0.328)	5.538 (0.699)
Skewness (*p*-value)	-0.238 (0.131)	-0.184 (0.244)	-0.302 (0.055)
Kurtosis (*p*-value)	0.134 (0.674)	0.225 (0.478)	0.058 (0.856)
Jarque-Bera (*p*-value)	2.445 (0.295)	1.855 (0.395)	3.673 (0.159)
LM (8) - ARCH in Residuals	6.600 (0.580)	7.485 (0.485)	6.530 (0.588)
Wald Test - Constant Variance	1207 (0.000)	282.4 (0.000)	607.5 (0.000)

"*a*": Q(*x*) is the Ljung-Box chi-squared statistic (and *p*-value) for the standardized residuals at lag *x*.
"*b*": Q(x) is the Ljung-Box chi-squared statistic (and *p*-value) for the squared standardized residuals at lag *x*.

Table 8.5 GARCH Estimates of the Predictability of Global Instruments

The general mean equation is: $R_{i,t} = b_0 + b_1 R_{i,t-1} + Z'_{t-1} \Gamma + e_{i,t}$. The conditional variance is: $h_{i,t} = c + \alpha (e^2_{i,t-1}) + \beta h_{i,t-1} + Z'_{t-1} \Lambda$.

R_i are LATADR, LATUDR, and FTWRLD which are the returns on the Latin American ADRs, the Latin American underlying stocks, and the FT-Actuaries world index. **Z** is a vector of instruments including XFTWRLD{1}, the lagged excess return on the world index, EUR01, the weekly one-month Eurodollar deposit rate, TERM, the US term premium, and DEFALT, the US default premium. Γ and Λ are the vectors of coefficients in the mean and variance equations. The term premium is measured by the difference between the yield on the 10-year Treasury Notes and the 90-day Treasury Bill. The default premium is the spread between the yield on the Moody's Baa- and Aaa-rated bonds. Coefficients and their robust *t*-statistics (in brackets) are reported in Panels A and B. The standard errors are estimated using quasi-maximum likelihood.

Panel A Conditional Mean

	b_0	b_1	XFTWRLD{1}	EUR01	TERM	DEFALT
LATADR	-0.931 (-0.415)	---	0.041 (0.228)	-0.720 (-7.718)	-1.173 (-6.819)	9.684 (3.201)
LATUDR	-1.493 (-1.195)	0.128 (1.87)	0.021 (0.165)	-0.539 (-3.664)	-0.842 (-3.338)	8.366 (3.894)
FTWRLD	2.726 (12.76)	---	-0.015 (-0.062)	-0.212 (-2.177)	-0.224 (-2.228)	-1.528 (-2.06)

Panel B Conditional Variance

	c	α	β	XFTWRLD{1}	EUR01	TERM	DEFALT
LATADR	5.435	0.136	0.685	-0.311	0.411	0.814	-9.512
	(2.460)	(2.312)	(5.989)	(-0.480)	(0.762)	(1.144)	(-1.468)
LATUDR	4.485	0.164	0.691	-0.074	-0.019	0.313	-5.206
	(3.270)	(2.277)	(9.684)	(-0.155)	(-0.075)	(1.105)	(-1.392)
FTWRLD	1.553	-0.035	-0.601	-0.202	-0.061	0.223	1.311
	(0.932)	(-0.488)	(-2.018)	(-1.923)	(-0.184)	(0.530)	(1.034)

Panel C Diagnostics of Standardized Residuals

	LATADR	LATUDR	FTWRLD
Loglikelihood	-436.450	-397.274	-179.594
Autocorrelation			
Q(4-) - Levels[a]	0.929 (0.920)	1.793 (0.774)	7.500 (0.112)
Q(8)	5.521 (0.701)	11.14 (0.194)	9.773 (0.281)
Q(4) - Squares[b]	0.464 (0.977)	1.250 (0.870)	2.534 (0.639)
Q(8)	2.902 (0.940)	7.585 (0.475)	5.551 (0.697)
Skewness (*p*-value)	-0.162 (0.302)	-0.121 (0.442)	-0.251 (0.111)
Kurtosis (*p*-value)	-0.052 (0.870)	0.063 (0.842)	-0.081 (0.798)
Jarque-Bera (*p*-value)	1.082 (0.582)	0.626 (0.731)	2.584 (0.275)
LM (8) - ARCH in Residuals	2.932 (0.939)	6.455 (0.596)	5.782 (0.672)
Wald Test - Constant Variance	192.6 (0.000)	318.2 (0.000)	65.11 (0.000)
Wald Test - GARCH Parameters	68.94 (0.000)	261.2 (0.000)	7.965 (0.019)
Wald Test - Instruments in Mean	4035 (0.000)	21.08 (0.000)	324.0 (0.000)
Wald Test - Instruments in Variance	4.139 (0.388)	2.312 (0.679)	47.85 (0.000)

"*a*": Q(*x*) is the Ljung-Box chi-squared statistic (and *p*-value) for the standardized residuals at lag *x*.
"*b*": Q(x) is the Ljung-Box chi-squared statistic (and *p*-value) for the squared standardized residuals at lag *x*.

Table 8.6 shows that while there is marginally significant asymmetry in the volatility of the ADRs ($\delta = 0.138$, t-value = 1.683), their underlying stocks do not display this feature ($\delta = 0.136$, t-value = 1.019). Interestingly, having treated the Latin American assets for asymmetry in their volatility the ARCH coefficients become insignificant without any change in the value of the GARCH coefficients. The world portfolio has significant asymmetric properties ($\delta = 0.144$, t-value = 5.433) but the model may be misspecified. If asymmetric responses in volatility is more likely for highly leveraged firms (or for firms in highly indebted countries (Bekaert and Harvey (1995)), then there is perhaps a simple interpretation of the failure to find asymmetry in the case of the ADRs and their underlying stocks. Since the listed ADRs used in this study are mainly capital-raising issues it is likely that the issuing firms are financed more by equity than by debt. Hence, the observed results are consistent with the lower leverage of these firms.

Table 8.6 Tests for Asymmetry in the Volatility of Latin American Assets

The most general mean equation is: $R_{i,t} = b_0 + b_1 R_{i,t-1} + e_{i,t}$. The variance is: $h_{i_t} = c + \alpha\varepsilon^2_{i,t-1} + \beta h_{i,t-1} + \delta S_t \varepsilon^2_{i,t-1}$,

where S is an indicator dummy: $S_t = \begin{Bmatrix} 1, \text{ if } \varepsilon_{t-1} < 0 \\ 0, \text{ if } \varepsilon_{t-1} \geq 0 \end{Bmatrix}$.

R_i are LATADR, LATUDR, and FTWRLD which are the returns on the Latin American ADRs, the Latin American underlying stocks, and the FT-Actuaries world index. Coefficients and their robust t-statistics (in brackets) are reported in Panel A. The standard errors are estimated using quasi-maximum likelihood.

Panel A Conditional Mean and Variance

	b_0	b_1	c	α	β	δ
LATADR	-0.013 (-0.064)	----	1.598 (0.996)	0.026 (0.513)	0.786 (5.359)	0.138 (1.683)
LATUDR	0.068 (0.446)	0.189 (2.746)	1.487 (2.157)	0.087 (0.992)	0.703 (9.164)	0.136 (1.019)
FTWRLD	0.190 (2.410)	----	2.884 (5.593)	-0.119 (-6.097)	-0.693 (-2.642)	0.144 (5.433)

Panel B Diagnostics of Standardized Residuals

	LATADR	LATUDR	FTWRLD
Loglikelihood	-441.198	-401.531	-183.693
Autocorrelation			
Q(4) (p-value) - Levels[a]	4.843 (0.304)	4.633 (0.327)	5.808 (0.214)
Q (8) (p-value)	7.323 (0.502)	11.92 (0.155)	6.806 (0.558)
Q(4) (p-value) - Squares[b]	0.337 (0.987)	3.997 (0.406)	5.163 (0.271)
Q(8) (p-value)	3.866 (0.869)	11.08 (0.197)	8.640 (0.374)
Skewness (p-value)	-0.112 (0.477)	-0.100 (0.525)	-0.288 (0.067)
Kurtosis (p-value)	0.077 (0.809)	0.182 (0.567)	0.009 (0.978)
Jarque-Bera (p-value)	0.560 (0.756)	0.730 (0.694)	3.321 (0.190)
LM(8): ARCH in residuals (p-value)	3.886 (0.867)	8.739 (0.365)	9.442 (0.306)
Wald: Constant variance (p-value)	121.5 (0.000)	202.6 (0.000)	87.40 (0.000)

"a": Q(x) is the Ljung-Box chi-squared statistic (and p-value) for the standardized residuals at lag x.
"b": Q(x) is the Ljung-Box chi-squared statistic (and p-value) for the squared standardized residuals at lag x.

IV. B. The Conditional ICAPM

In this section I ascertain if the proposed ICAPM is valid. Two versions of the model are presented. The first assumes that the prices of world market and world currency risks are constant. The second model allows for time-variation in the prices of risks, where the time-variation is captured by the instruments. Both models assume that the Latin American ADRs, their underlying stocks, and the world equities markets are integrated. It also assumes that the currency markets are integrated with the equities markets.

Constant and Equal Prices of Risks. The system of equations treats the prices of market and currency risk as constant but allows the quantity of risk to vary with time. Specifically, the following conditional mean model is estimated for each market:

$$r_{it} = \exp(\varphi^*)\mathrm{cov}(r_{it}, r_{mt} | \Omega_{t-1}) + \kappa \mathrm{cov}(r_{it}, f_t | \Omega_{t-1}) + \varepsilon_{it} \qquad i = 1,\ldots,4. \qquad (8.9)$$

Table 8.7 displays the prices of risks, the conditional variances, robust Wald tests, and several diagnostics of the standardized residuals. In Panel A the price of market risk, φ, is 0.0725 (φ^* = -2.624, t-statistic = -3.613). This indicates that world market risk is significant in explaining the returns of the assets in the system of equations. The price of currency risk, κ, (0.059, t-statistic = 1.059) is positive but not significant at the conventional levels. One interpretation is that the exposure to currency risk is not priced in the markets under review. However, this could be premature since even if the constant price of currency risk does not impact on the cross-section of returns, the

Table 8. 7 Estimates of the Conditional ICAPM - Constant and Equal Prices of Risks

The model estimated for the conditional mean is:

$$r_{it} = \exp(\varphi^*)\text{cov}(r_{it}, r_{mt} | \Omega_{t-1}) + \kappa\text{cov}(r_{it}, f_t | \Omega_{t-1}) + \varepsilon_{it} \qquad i = 1,\ldots,4.$$

$r_{i,t}$ are XLATADR, XLATUDR, XFTWRLD which are the excess returns on the Latin American ADRs, the Latin American underlying stocks, the FT-Actuaries world index, and TWIFXR is the log-price differences of a trade-weighted index of the exchange rates of the top ten economies with the US dollar. All t-values in Panel A are based on a quasi-maximum likelihood estimation robust to non-normality in the residuals. All residual diagnostics are based on standardized residuals. LB(x) is the Ljung-Box chi-squared statistics for testing the null hypothesis of zero autocorrelation up to the xth lag. LM is the Lagrange multiplier test (chi-squared statistic and p-value) for ARCH in the residuals, with 8 degrees of freedom.

Panel A Conditional Mean

	XLATADR	XLATUDR[a]	XFTWRLD	TWIFXR
φ^* **(Market Risk)**			-2.624 (-3.613)	
κ **(Currency Risk)**				0.059 (1.059)

Conditional Variance[b]

	XLATADR	XLATUDR	XFTWRLD	TWIFXR
A_I	0.293 (5.541)	0.326 (6.553)	0.103 (1.070)	-0.230 (-3.397)
B_I	0.919 (47.70)	0.872 (103.5)	0.796 (2.061)	0.945 (35.29)

Panel B Specification Tests

	XLATADR	XLATUDR	XFTWRLD	TWIFXR
H_0: Zero prices of risks - χ^2 (2)		16.151 (0.000)		
Avg. Prediction Error [t-value][c]	-0.242 [-0.064]	-0.125 [-0.039]	-0.027 [-0.021]	-0.031 [-0.026]

Panel C Standardized Residual Diagnostics

	XLATADR	XLATUDR	XFTWRLD	TWIFXR
Skewness (p-value)	-0.226 (0.151)	-0.202 (0.199)	-0.321 (0.042)	0.268 (0.089)
Kurtosis (p-value)	0.110 (0.730)	0.340 (0.285)	0.103 (0.747)	0.858 (0.007)
Jarque-Bera (p-value)	2.164 (0.339)	2.788 (0.248)	4.214 (0.122)	10.23 (0.006)
Autocorrelation (Level)				
LB (4) (p-value)	5.759 (0.218)	8.615 (0.071)	5.942 (0.203)	4.254 (0.373)
LB (8) (p-value)	7.400 (0.494)	14.24 (0.076)	6.870 (0.551)	7.293 (0.505)
Autocorrelation (Squared)				
LB (4) (p-value)	1.040 (0.904)	3.984 (0.408)	5.863 (0.210)	3.259 (0.515)
LB (8) (p-value)	6.658 (0.574)	11.37 (0.182)	8.187 (0.415)	5.132 (0.743)
LM(8) - (ARCH in Residuals)	6.665 (0.573)	9.385 (0.311)	9.627 (0.292)	5.840 (0.665)
Wald: Constant variance - χ^2 (32)	429341 (0.000)			
Loglikelihood	-937.708			

a) An AR(1) term with coefficient (t-value) of 0.084 (3.265) was included in this equation.
b) A non-diagonal version of the model caused misspecification and convergence problems.
c) Based on the unstandardized residuals from the conditional mean.

time-varying price of currency risk could be significant (see, e.g., Dumas and Solnik (1995), De Santis and Gerard (1996b)).

Panel A also includes the GARCH (1,1) estimates of the conditional variances. The parameters in the matrices $\mathbf{A}_1$ and $\mathbf{B}_1$ are all significant (except for the ARCH effect of the world portfolio as previously observed in the simple univariate model). The usual relation found in higher-frequency data where the coefficients in $\mathbf{A}_1$ (representing the response of the contemporaneous conditional variance to the past innovations) are smaller than those in $\mathbf{B}_1$ (representing the lagged variance) is evident here. The robust Wald test rejects the hypothesis of constant variance at less than the 0.001 level. Specification tests in Panel B suggest that the model explains the data fairly well. The robust Wald test rejects the null hypothesis that both prices of risk are zero at less than the 1% level. The model errors are on average not significantly different from zero and are much smaller than the means of the series in Table 8.1.

The diagnostics of the standardized residuals in Panel C further validate the model. There is no evidence of nonstationarity of the conditional variances. For the diagonal GARCH(1,1) model, weak stationarity requires that $(A_i^2 + B_i^2) < 1, \forall i$. That is, stationarity is violated if a variance coefficient is equal to or greater than one or if the square of the coefficients sum to one or more (Engle and Kroner (1993)). Neither the Ljung-Box statistic nor the Lagrange multiplier test detects any remaining ARCH errors in the squared standardized residuals $(\varepsilon_t^2 h_t^{-1})$. However, there is marginally significant autocorrelation remaining in the standardized residuals $(\varepsilon_t h_t^{-0.5})$ of the underlying stocks even after including an AR(1) error term, and the residuals of the world currency market are not normally distributed.

Time-Varying and Equal Prices of Risks. The statistical insignificance of the (constant) price of world currency risk might have resulted from the inability of the previous specification to capture time-variation in the price of risk. The model which incorporates the dynamics of the prices of risk is informative as to the variables that are driving the changes. The conditional mean of this model is specified as follows:

$$r_{it} = \varphi_{t-1} \operatorname{cov}(r_{it}, r_{mt} | \Omega_{t-1}) + \kappa_{t-1} \operatorname{cov}(r_{it}, f_t | \Omega_{t-1}) + \varepsilon_{i,t} \quad i = 1,\dots,4 \qquad (8.10)$$

$$\text{where } \varphi_{t-1} = \exp(\mathbf{Z}'_{t-1}\Pi) \text{ and } \kappa_{t-1} = (\mathbf{Z}'_{t-1}\Theta).$$

The instruments are a constant, the lagged excess return on the world portfolio (XFTWRLD{1}), the weekly one-month Eurodollar rate (EUR01), the spread between the US 10-year Treasury Note and the one-month US Treasury Bill (TERM), and the spread between the Baa- and Aaa-rated corporate bonds (DEFALT). Table 8.8 reports the results of this model. In Panel A the lagged world index (Π = -1.17, t = -1.937) and the term structure (Π = -1.068, t = -1.669) marginally impact on the price of market risk. On the other hand, all interest-rate related variables predict the price of currency risk.

The more important results are presented in Panel B. First, the null hypotheses that market risk is not priced (and that the price of market risk is constant) cannot be rejected at the usual level of significance, p-value = 0.476 (p-value = 0.340). Next, the null hypothesis that the price of currency risk is zero is strongly rejected at less than the 1% level and, finally, the null hypothesis that the price of currency risk is constant is also rejected at a similar level of significance. These result are in contrast to those found when the model assumes constant risk prices. One possible explanation is that in the case where the model captures time-variation in the risk prices imposing equal prices of risk across all four markets does not describe the data very well. This is supported by the test of predictability of the unstandardized residuals from the mean equations of the individual markets displayed in the table. It is evident that the model leaves some predictability in the residuals of the Latin American assets. The null hypothesis that the instruments do not predict the residuals is rejected with p-values less than the 0.05 level of significance in both cases. However, since the averages of the residuals are less than the means of the series, the model does explain some of the variation in the data. In the next section where the markets are individually priced the reason for these results become clearer.

The results thus far suggest that both market and currency risks are priced in the system of equations and that the proposed two-factor model fits the data reasonably well. However, it is evident that the significance of the results is influenced by the manner in which the dynamics of the prices of risk are modeled. Imposing equal prices of risks on the Latin American and world markets could lead to underpricing of the world risks. In the next section which focuses on the main objective of this paper I estimate a more general model which allows individual pricing of both types of risks.

Table 8.8 Estimates of the Conditional ICAPM - Time-Varying and Equal Prices of Risks

The model estimated for the conditional mean is:

$$r_{it} = \varphi_{t-1} \operatorname{cov}(r_{it}, r_{mt} | \Omega_{t-1}) + \kappa_{t-1} \operatorname{cov}(r_{it}, f_t | \Omega_{t-1}) + \varepsilon_{it} \qquad i = 1,\ldots,4$$

$$\text{where } \varphi_{t-1} = \exp(\mathbf{Z}'_{t-1}\Pi) \quad \text{and} \quad \kappa_{t-1} = (\mathbf{Z}'_{t-1}\Theta).$$

r_i are XLATADR, XLATUDR, XFTWRLD which are the excess returns on the Latin American ADRs, the Latin American underlying stocks, the FT-Actuaries world index, and TWIFXR is the log-price differences of a trade-weighted index of the exchange rates of the top ten economies with the US dollar. **Z** is a vector of instruments including EUR01, TERM, and DEFALT which are the weekly one-month Eurodollar deposit rate, the US term premium, and the US default premium. The term premium is measured by the difference between the yield on the 10-year Treasury Notes and the 90-day Treasury Bill. The default premium is the spread between the yield on the Moody's Baa- and Aaa-rated bonds. All t-values (in brackets) in Panel A are based on a quasi-maximum likelihood estimation robust to non-normality in the residuals. All residual diagnostics are based on standardized residuals. LB(x) is the Ljung-Box chi-squared statistics for testing the null hypothesis of zero autocorrelation up to the xth lag. LM is the Lagrange multiplier test (χ^2 statistic and p-value) for ARCH in the residuals, with 8 degrees of freedom.

Panel A Conditional Mean

	XLATADR	XLATUDR[a]	XFTWRLD	TWIFXR
Π (Market Risk)				
Constant			13.09 (1.261)	
XFTWRLD{1}			-1.170 (-1.937)	
EUR01			-0.965 (-1.270)	
TERM			-1.068 (-1.669)	
DEFALT			-15.34 (-1.341)	
Θ (Currency Risk)				
Constant				0.214 (7.832)
XFTWRLD{1}				-0.043 (-1.079)
EUR01				-0.139 (-3.964)
TERM				-0.166 (-2.855)
DEFALT				1.179 (3.499)
Conditional Variance[b]				
A_1	0.282 (4.628)	0.342 (3.215)	0.068 (0.713)	- 0.244 (-4.015)
B_1	0.924 (54.99)	0.870 (20.19)	0.878 (15.91)	0.935 (31.35)

Panel B Specification Tests

H_0: Zero prices of market risk	- χ^2 (5)	4.530 (0.476)
H_0: Constant price of market risk	- χ^2 (4)	4.524 (0.340)
H_0: Zero prices of currency risk	- χ^2 (5)	119.2 (0.000)
H_0: Constant price of currency risk	- χ^2 (4)	27.55 (0.000)

Tests of the Predictability of the Instruments on the Unstandardized Residuals[c]

	XLATADR	XLATUDR	XFTWRLD	TWIFXR
H_0: Zero Predictability of Instruments - χ^2 (4) (p-value)	10.87 (0.028)	9.67 (0.046)	4.881 (0.300)	0.899 (0.925)
Avg. Prediction Error [t-value][d]	-0.238 [-0.064]	-0.120 [-0.038]	-0.007 [-0.001]	-0.026 [-0.022]

Panel C Standardized Residual Diagnostics

	XLATADR	XLATUDR	XFTWRLD	TWIFXR
Skewness (p-value)	-0.248 (0.115)	-0.197 (0.212)	-0.313 (0.047)	0.310 (0.049)
Kurtosis (p-value)	0.063 (0.844)	0.301 (0.344)	0.004 (0.990)	0.878 (0.006)
Jarque-Bera (p-value)	2.509 (0.285)	2.452 (0.294)	3.924 (0.141)	11.55 (0.003)
Autocorrelation (Level)				
LB (4) (p-value)	5.103 (0.277)	7.855 (0.097)	5.312 (0.257)	3.826 (0.430)
LB (8) (p-value)	6.876 (0.550)	13.14 (0.107)	6.575 (0.583)	6.534 (0.588)
Autocorrelation (Squared)				
LB (4) (p-value)	1.405 (0.843)	4.763 (0.312)	7.102 (0.131)	2.820 (0.588)
LB (8) (p-value)	6.254 (0.619)	12.12 (0.146)	9.605 (0.294)	4.617 (0.798)
LM(8) - (ARCH in Residuals)	6.160 (0.629)	9.792 (0.280)	10.86 (0.210)	5.279 (0.727)
Wald: Constant variance - χ^2 (8)	39720 (0.000)			
Loglikelihood	-930.955			

a) An AR(1) term with coefficient (t-value) of 0.087 (2.122) was included in this equation.
b) A non-diagonal version of the model caused misspecification and convergence problems.
c) Based on OLS regression of the residuals on a constant and the instruments with heteroscedasticity-consistent standard errors.
d) Based on the unstandardized residuals from the conditional mean.

IV. C. Tests of Integration

To test if the Latin American markets are integrated, in this section I adopt a version of the ICAPM in which each equation in the system is allowed to price both market and currency risks individually. The advantage of this approach is that it nests the assumption of integrated markets while at the same time allows us to detect any segmentation. If the Latin American markets are integrated, then the prices of risks of the ADRs and their underlying stocks will be equal. Otherwise, the risk prices will be different.

Constant and Individual Prices of Risks. The following conditional mean model assumes constant but individual prices of risk:

$$r_{it} = \exp(\varphi_i^*)\mathrm{cov}(r_{it}, r_{mt} | \Omega_{t-1}) + \kappa_i \mathrm{cov}(r_{it}, f_t | \Omega_{t-1}) + \varepsilon_{i,t} \quad i = 1,\ldots,4 \tag{8.11}$$

Table 8.9 reports several interesting results. First, in Panel A the price of market risk is individually significant for each market. Second, currency risk is not priced in the market for ADRs (κ = 0.269, t = 1.102) but it is marginally significant for the underlying stocks (κ = 0.363, t = 1.894) and highly significant for the world portfolio (κ = 1.613, t = 25.85) and the world currency market (κ = 0.435, t = 7.623). Third, from Panel B the null hypothesis that market risk is not priced can be rejected for the system as a whole and also for the Latin American markets. Fourth, the null

Table 8.9 Estimates of the Conditional ICAPM - Constant and Individual Prices of Risk

The model estimated in the mean is:

$$r_{it} = \exp(\varphi_i^*)\mathrm{cov}(r_{it}, r_{mt} | \Omega_{t-1}) + \kappa_i \mathrm{cov}(r_{it}, f_t | \Omega_{t-1}) + \varepsilon_{i,t} \qquad i = 1,\ldots,4$$

r_i are XLATADR, XLATUDR, XFTWRLD which are the excess returns on the Latin American ADRs, the Latin American underlying stocks, the FT-Actuaries world index, and TWIFXR is the log-price differences of a trade-weighted index of the exchange rates of the top ten economies with the US dollar. All t-values in Panel A are based on a quasi-maximum likelihood estimation robust to non-normality in the residuals. All residual diagnostics are based on standardized residuals. LB(x) is the Ljung-Box chi-squared statistics for testing the null hypothesis of zero autocorrelation up to the xth lag. LM is the Lagrange multiplier test (chi-squared statistic and p-value) for ARCH in the residuals, with 8 degrees of freedom.

Panel A Conditional Mean

	XLATADR	XLATUDR[a]	XFTWRLD	TWIFXR
φ^* (**Market Risk**)	-3.662 (-5.163)	-3.562 (-5.376)	-0.684 (-6.823)	0.259 (5.591)
κ (**Currency Risk**)	0.269 (1.102)	0.363 (1.894)	1.613 (25.85)	0.435 (7.623)
Conditional Variance[b]				
A_i	0.317 (6.045)	0.329 (8.966)	0.080 (2.945)	-0.397 (-5.350)
B_i	0.906 (67.42)	0.871 (172.7)	0.637 (18.68)	-0.494 (-1.840)

Panel B Specification Tests

ALL MARKETS

H_0: Zero prices of market risk - χ^2 (4)	208.9 (0.000)
H_0: Zero prices of currency risk - χ^2 (4)	1656 (0.000)

	XLATADR	XLATUDR	XFTWRLD	TWIFXR
Avg. Prediction Error [t-value][c]	-0.184 [-0.049]	-0.109 [-0.034]	-0.050 [-0.039]	-0.004 [-0.003]

LATIN AMERICAN MARKETS

H_0: Zero prices of market risk - χ^2 (2)	29.45 (0.000)
H_0: Zero prices of currency risk - χ^2 (2)	3.589 (0.166)

Panel C Robust Wald Tests of Integration of the Latin American Markets

H_0: Equal prices of market risk	- XLATADR and XLATUDR - χ^2 (1)	0.104 (0.747)
H_0: Equal prices of currency risk	- XLATADR and XLATUDR - χ^2 (1)	0.198 (0.656)
H_0: Equal prices of market risk	- XLATADR and XFTWRLD - χ^2 (1)	20.06 (0.000)
H_0: Equal prices of currency risk	- XLATADR and XFTWRLD - χ^2 (1)	22.44 (0.000)
H_0: Equal prices of market risk	- XLATUDR and XFTWRLD - χ^2 (7)	23.20 (0.000)
H_0: Equal prices of currency risk	- XLATUDR and XFTWRLD - χ^2 (7)	32.94 (0.000)

Panel D Standardized Residual Diagnostics

	XLATADR	XLATUDR	XFTWRLD	TWIFXR
Skewness (p-value)	-0.230 (0.145)	-0.211 (0.180)	-0.290 (0.065)	0.361 (0.039)
Kurtosis (p-value)	0.106 (0.740)	0.360 (0.257)	0.041 (0.897)	1.013 (0.001)
Jarque-Bera (p-value)	2.222 (0.329)	3.081 (0.214)	3.385 (0.184)	14.50 (0.000)
Autocorrelation (Level)				
LB (4) (p-value)	5.974 (0.201)	9.462 (0.051)	6.020 (0.198)	7.587 (0.108)
LB (8) (p-value)	7.498 (0.484)	14.62 (0.067)	6.797 (0.559)	13.10 (0.109)
Autocorrelation (Squared)				
LB (4) (p-value)	0.993 (0.911)	4.467 (0.347)	5.780 (0.216)	3.295 (0.510)
LB (8) (p-value)	7.258 (0.509)	12.85 (0.117)	8.246 (0.410)	8.840 (0.356)
LM(8) - (ARCH in Residuals)	7.189 (0.516)	10.44 (0.235)	9.886 (0.273)	9.348 (0.314)
Wald: Constant variance - χ^2 (8)	121776 (0.000)			
Loglikelihood	-939.369			

a) An AR(1) term with coefficient (t-value) of 0.085 (2.2935) was included in this equation.
b) A non-diagonal version of the model caused misspecification and convergence problems.
c) Based on the unstandardized residuals from the conditional mean.

hypothesis that the prices of currency risk for the Latin American assets are jointly zero cannot be rejected (p-value = 0.166), though it can be rejected for the system as a whole. There are no misspecification errors reported in Panel D, save for the presence of marginally significant higher-order autocorrelation in the underlying stocks.

Panel C reports several hypotheses related to market integration which is the matter of interest here. However, to facilitate the comparison of the above model with that which allows for time-varying prices of risks, this discussion is done below.

Time-Varying and Individual Prices of Risks. This the most general model to be estimated so far allows for time variation in the prices of risks when the prices are allowed to differ across markets. The conditional mean equation is:

$$r_{it} = \varphi_{i,t-1} \operatorname{cov}(r_{it}, r_{mt} | \Omega_{t-1}) + \kappa_{i,t-1} \operatorname{cov}(r_{it}, f_t | \Omega_{t-1}) + \varepsilon_{i,t} \quad i = 1,\dots,4 \tag{8.12}$$

where $\varphi_{i,t-1} = \exp(\mathbf{Z}'_{t-1}\Pi_i)$ and $\kappa_{i,t-1} = (\mathbf{Z}'_{t-1}\Theta_i)$.

Table 8.10 reports the results. In Panel A there are several individually significant coefficients in each market in the mean equations. It is clear that the lagged world portfolio and the short-term interest rate are most influential on the price of market risk, while the short-term interest rate and the term premium drive most of the variation in the price of currency risk. Specification tests in Panel B indicate that the null hypotheses of zero price of market risk, zero price of currency risk, constant price of market risk, and constant price of currency risk, respectively, are rejected at less

Table 8.10 Estimates of the Conditional ICAPM - Time-Varying and Individual Prices of Risks

The model estimated for the conditional mean is:

$$r_{it} = \varphi_{i,t-1} \operatorname{cov}(r_{it}, r_{mt} | \Omega_{t-1}) + \kappa_{i,t-1} \operatorname{cov}(r_{it}, f_t | \Omega_{t-1}) + \varepsilon_{i,t} \qquad i = 1,\ldots,4$$

$$\text{and } \varphi_{i,t-1} = \exp(\mathbf{Z}'_{t-1}\Pi_i) \text{ and } \kappa_{i,t-1} = (\mathbf{Z}'_{t-1}\Theta_i).$$

r_i are XLATADR, XLATUDR, XFTWRLD which are the excess returns on the Latin American ADRs, the Latin American underlying stocks, the FT-Actuaries world index, and TWIFXR is the log-price differences of a trade-weighted index of the exchange rates of the top ten economies with the US dollar. **Z** is a vector of instruments including EUR01, TERM, and DEFALT which are the weekly one-month Eurodollar deposit rate, the US term premium, and the US default premium. The term premium is measured by the difference between the yield on the 10-year Treasury Notes and the 90-day Treasury Bill. The default premium is the spread between the yield on the Moody's Baa- and Aaa-rated bonds. All t-values in Panel A are based on a quasi-maximum likelihood estimation robust to non-normality in the residuals. All residual diagnostics are based on standardized residuals. LB(x) is the Ljung-Box chi-squared statistics for testing the null hypothesis of zero autocorrelation up to the xth lag. LM is the Lagrange multiplier test (χ^2 statistic and p-value) for ARCH in the residuals, with 8 degrees of freedom.

Panel A Conditional Mean

	XLATADR	XLATUDR[a]	XFTWRLD	TWIFXR
Π (Market Risk)				
Constant	-6.697 (-1.466)	-7.079 (-16.43)	-45.09 (-2.239)	2.362 (0.878)
XFTWRLD{1}	0.857 (2.220)	-2.240 (-24.21)	-1.073 (-2.341)	0.257 (1.294)
EUR01	1.423 (1.978)	-1.617 (-17.04)	6.962 (2.301)	-0.755 (-1.290)
TERM	2.145 (1.265)	-2.400 (-18.10)	0.776 (0.967)	-0.080 (-0.096)
DEFALT	-11.44 (-0.864)	-10.08 (-16.95)	1.018 (0.073)	1.384 (0.407)
Θ (Currency Risk)				
Constant	5.834 (1.264)	4.701 (0.605)	-4.496 (-1.594)	1.693 (1.743)
XFTWRLD{1}	-0.086 (-0.541)	0.122 (1.002)	0.039 (0.303)	0.067 (1.026)
EUR01	-1.830 (-2.715)	-1.606 (-2.799)	0.546 (1.860)	-0.405 (-2.795)
TERM	-1.551 (-2.389)	-1.100 (-2.226)	0.422 (1.414)	-0.277 (-0.982)
DEFALT	8.300 (1.885)	7.427 (0.763)	1.425 (0.447)	1.639 (1.001)
Conditional Variance[b]				
A_1	0.293 (5.506)	0.373 (6.335)	0.127 (1.179)	-0.237 (-5.824)
B_1	0.917 (45.29)	0.852 (25.13)	0.831 (9.507)	0.930 (71.17)

Panel B Specification Tests

ALL MARKETS		
H_0: Zero prices of market risk	- χ^2 (20)	311094 (0.000)
H_0: Constant price of market risk	- χ^2 (16)	8614.3 (0.000)
H_0: Zero prices of currency risk	- χ^2 (20)	45.80 (0.001)
H_0: Constant price of currency risk	- χ^2 (16)	42.79 (0.000)
LATIN AMERICAN MARKETS		
H_0: Zero prices of market risk	- χ^2 (10)	142472 (0.000)
H_0: Constant price of market risk	- χ^2 (8)	4568.8 (0.000)
H_0: Zero prices of currency risk	- χ^2 (10)	18.48 (0.047)
H_0: Constant price of currency risk	- χ^2 (8)	17.78 (0.023)

Tests of the Predictability of the Instruments on the Unstandardized Residuals[c]

	XLATADR	XLATUDR	XFTWRLD	TWIFXR
H_0: Zero Predictability of Instruments - χ^2 (4) (p-value)	2.522 (0.641)	2.538 (0.638)	0.633 (0.959)	2.246 (0.691)
Avg. Prediction Error [t-value][d]	-0.320 [-0.088]	-0.217 [-0.069]	-0.021 [-0.017]	-0.089 [-0.076]

Panel C Robust Wald Tests of Integration of the Latin American Markets

H_0: Equal prices of market risk	- XLATADR and XLATUDR - χ^2 (5)	693.4 (0.000)
H_0: Equal prices of currency risk	- XLATADR and XLATUDR - χ^2 (5)	4.248 (0.514)
H_0: Equal prices of market risk	- XLATADR and XFTWRLD - χ^2 (5)	23.58 (0.000)
H_0: Equal prices of currency risk	- XLATADR and XFTWRLD - χ^2 (5)	12.94 (0.024)
H_0: Equal prices of market risk	- XLATUDR and XFTWRLD - χ^2 (5)	447.4 (0.000)
H_0: Equal prices of currency risk	- XLATUDR and XFTWRLD - χ^2 (5)	13.49 (0.019)

Panel D Standardized Residual Diagnostics

Skewness (p-value)	-0.121 (0.441)	-0.134 (0.393)	-0.391 (0.013)	0.264 (0.094)
Kurtosis (p-value)	0.189 (0.552)	0.164 (0.604)	0.066 (0.836)	0.848 (0.008)
Jarque-Bera (p-value)	0.945 (0.624)	0.993 (0.609)	6.157 (0.046)	9.974 (0.007)
Autocorrelation (Level)				
LB (4) (p-value)	1.233 (0.873)	3.125 (0.537)	5.107 (0.276)	7.370 (0.118)
LB (8) (p-value)	3.805 (0.874)	11.54 (0.173)	6.676 (0.572)	13.25 (0.104)
Autocorrelation (Squared)				
LB (4) (p-value)	2.436 (0.656)	2.533 (0.639)	5.640 (0.228)	5.851 (0.211)
LB (8) (p-value)	5.655 (0.686)	9.172 (0.328)	7.493 (0.484)	10.08 (0.260)
LM (8) - (ARCH in Residuals)	5.272 (0.728)	7.438 (0.490)	8.481 (0.388)	13.39 (0.099)
Wald: Constant variance - $\chi^2(8)$	76120 (0.000)			
Loglikelihood	-911.421			

a) An AR(1) term with coefficient (t-value) of 0.068 (2.066) was included in this equation.
b) A non-diagonal version of the model caused misspecification and convergence problems.
c) Based on OLS regression of the residuals on a constant and the instruments with heteroscedasticity-consistent standard errors.
d) Based on the unstandardized residuals from the conditional mean.

than the 1% level for all the markets together and at the 5% level for the Latin American markets.

The model seems to fit the data well as the unstandardized residuals are not predicted by the instruments and the average prediction errors are small relative to the means of the series. It does appear that the failure to find significant time-varying price of market risk in the previous case (Table 8.8) arises from the imposition of equal prices across the four markets. Furthermore, the diagnostics (Panel D) suggest that it fits the data rather well, hence, any conclusions drawn are unlikely to be affected by model misspecification. For instance, there is no autocorrelation in levels, no remaining ARCH errors, the instruments do not predict the residuals, and the average prediction errors are relatively small.

To facilitate the conclusions about the integration of the Latin American markets I select between the model which assumes constant, individual prices of risks (equation

(8.11), Table 8.9) and that which assumes time-varying, individual prices of risks (equation (8.12), Table 8.10). The latter model is the more general and nests equation (8.11), which is the restricted model with the null hypotheses that the prices of market and currency risks are constant. From Panel B of Table 8.10 the null hypotheses are rejected at less than the 5% level for all markets and also for the Latin American markets. Hence, the model that assumes time-variation in the prices of risks and individual prices of risks fits the data better. This model (Table 8.10), therefore, provides the basis on which the conclusions about integration are drawn.

Panel C of Table 8.10 presents several hypothesis tests of the integration of the Latin American markets. First, the null hypothesis of equal prices of market risk between the ADRs and their underlying stocks is rejected (p-value < 0.000). Second, at the conventional levels we cannot reject the hypothesis of equal prices of currency risk (p-value = 0.514). Third, the model rejects the null hypotheses that the ADRs and their underlying stocks, respectively, have the same price of market and currency risks as the world market portfolio. As is explained below this has implications for the types of barriers to international investment that exist in the Latin American markets. The model selected by the above (Wald) test (equation (8.12)) is consistent with some previous studies which find that the emerging markets are predictable and only partially integrated into the world capital market.

As discussed in the introduction, the test of market integration based on the differences in the prices of risks between the ADRs and their underlying assets overcomes the joint-hypothesis problem. If the regional markets are integrated, then the ADRs and their underlying stocks are perfect substitutes. Hence, it is not possible that the ADRs are priced using one asset pricing model and their underlying stocks using another. The implication of this is that even if the wrong model has been applied to the data, if the markets are integrated, then this model would still elicit the same (possibly wrong) prices of risks. The null hypothesis of equal risk prices would, therefore, not be rejected. In other words, that the prices of risks are different between these assets is an indication of market segmentation and not a rejection of the asset pricing model.

First, the rejection of the null hypothesis of equal prices of market risk between the ADRs and their underlying assets strongly supports the contention that the markets for the Latin American assets are not fully integrated, this despite the fact that they both price currency risks equally. This difference in the prices of market risk may be reflecting the relative influences of global and regional news on the two sets of regional assets. For instance, local (regional) investors may react differently to regional and global news, placing more emphasis on the former, while investors in the ADRs react similarly to regional and international news. A possible explanation for the equality of the prices of currency risk for the ADRs and their underlying stocks may be that currency-related news about Latin America is more international than domestic and so is less affected by information asymmetry. Furthermore, it could also be related to the sensitivity of the Latin American economies to exchange rate fluctuations. Given the (perception of) instability of exchange rates in the region the marginal investor in local stocks and the marginal investor in the ADRs are particularly alert to exchange rate-related news that may impact on these markets. This being the case, if both investors process currency-related news efficiently without causing over- or under-reaction, then it is likely that the prices of currency risk will be the same for the ADRs and the underlying stocks. This is corroborated by Bailey and Chung (1995) who find that exchange rate risk is priced by local Mexican stocks, by Bailey, Chan, and Chung (1998) who find that US investors in the region's ADRs reacted rationally to the information in exchange rate fluctuations during the Mexican peso crash of December 1994, and by research elsewhere in this thesis which showed that the Latin American ADRs and country funds failed to provide diversification for US investors after the peso crash.

Second, while it is clear that the Latin American markets are not fully integrated, it would be imprudent to conclude that they are completely segmented. That is, as in Errunza and Losq (1985a) and Errunza, Losq, and Padmanabhan (1992), the markets are best described as being partially integrated. This characterization is supported by, a) the significance of the prices of world portfolio and world currency risks in these markets, b) the ability of the world information variables to predict not only the returns but also the prices of risks of the Latin American markets, and most importantly c) the equality of the price of the world currency risk between the ADRs and their underlying stocks.

Third, the rejection of the null hypotheses of equality of the prices of risks for both the ADRs and the underlying assets on the one hand and the prices of risks for the world market portfolio on the other (Table 8.10, Panel C) has policy implications. If the observed segmentation were due solely to indirect (non-legal) barriers to international investment such as poor reporting of accounting information in the local markets, then this could explain the differences in the prices of risks between the underlying assets and the world market portfolio. An alternative reason would be required for the differences in risk prices between the ADRs and the world market portfolio since the listing of ADRs on the main exchanges of the US would have surmounted these barriers. That both hypotheses are rejected indicates that there are legal barriers existing in the Latin American markets. In Mexico, for instance, there are still some industries such as banking and others considered "strategic" that place restrictions on foreign ownership. The same holds for Chile. Harvey (1995) cites Chile as one of the least investable of the markets covered by the IFC Emerging Markets Database. It is clear that despite the laudable efforts of the region's authorities since 1989 to bring their capital markets in line with the expectations of international investors, there is still more to be done. What is less clear is the role of foreign investors' attitude to investing overseas as an indirect barrier.

IV. D. Some Further Diagnostics

In this section I further validate the results of the previous model. Partial integration of the Latin American markets have other implications which can easily be tested within the framework of the above test of integration. For instance, that local/regional instruments predict the prices of risk, that the Latin American markets' own variances are priced, and that there are non-zero intercepts are all consistent with partial integration. Therefore, I estimate a very general model which includes the global instruments as regressors, an intercept for each market, the own variances of the Latin

American markets, and two regional information variables along with the market and currency risks.

The conditional mean of the estimated model is:

$$\begin{aligned} r_{it} &= a_i + \mathbf{Z}'_{t-1}\Psi_i + \theta_j \operatorname{var}(r_{jt} \mid \Omega_{t-1}) + \varphi_{i,t-1}\operatorname{cov}(r_{it}, r_{mt} \mid \Omega_{t-1}) \\ &\quad + \kappa_{i,t-1}\operatorname{cov}(r_{it}, f_t \mid \Omega_{t-1}) + \varepsilon_{i,t} \qquad \forall i \end{aligned} \tag{8.13}$$

where $\varphi_{i,t-1} = \exp(\mathbf{Z}'_{t-1}\Pi_i)$ and $\kappa_{i,t-1} = (\mathbf{Z}'_{t-1}\Theta_i)$. $Var(r_{jt})$, j = 1 or 2, indicates that only the variance of the ADRs or of the underlying stocks is added to their respective mean equation. **Z** now contains both global and regional instruments, and a_i are intercepts.

The results reported in Table 8.11 are supportive of the view that the Latin American markets are only partially integrated into the world capital markets. From Panel A the regional instruments IFCLAR and MEXFXR are significant in predicting the price of market risk for the ADRs (Π = 0.56 and 0.526, t = 4.41 and 5.784, respectively) and for the underlying stocks (Π = 3.566 and 3.604, t = 6.364 and 6.973, respectively). The local instruments are not significant in predicting the price of currency risk. The significance of the instruments supports the conclusion of partial integration as the world risk factors are unable to capture fully the variation in the Latin American assets. Furthermore, the fact that the local instruments do not predict the price of currency risk for the Latin American assets, while they predict the price of market risk, lend some support to the proposition that the currency-related news in Latin America is more international than domestic and that foreign investors may be less subjected to information asymmetry with regards to exchange rate information.

In Panel C, the model rejects the null hypotheses of equality of the market and currency prices of risks, respectively, for the ADRs and their underlying stocks. However, the hypotheses of equal variance risks and equal additional predictability of the instrumental variables (as regressors) cannot be rejected at the conventional levels of significance. The model also rejects the null hypotheses of equality of the prices of risks for the ADRs and the underlying stocks, respectively, and the prices of risks for the world market. The intercepts are not individually significant in any market and only the ADRs price their own variance. The current model reinforces the conclusion of partial integration.

It is clear (Panel D) that the above results are unlikely to be driven by any misspecification of the model. For instance, the conditional variance is well specified with all significant coefficients of the relative magnitudes expected. There is no significant autocorrelation (at the 5% level) in either the mean or the variance and the departure from normality is accounted for by the quasi-maximum likelihood estimation.

Table 8.11 Robustness Test (of Partial Integration) with Time-Varying and Individual Prices of Risks

The model estimated for the conditional mean is:

$$r_{it} = a_i + \mathbf{Z}'_{t-1}\Psi_i + \theta_j \operatorname{var}(r_{jt} | \Omega_{t-1}) + \varphi_{i,t-1} \operatorname{cov}(r_{it}, r_{mt} | \Omega_{t-1})$$
$$+\kappa_{i,t-1} \operatorname{cov}(r_{it}, f_t | \Omega_{t-1}) + \varepsilon_{i,t} \qquad \forall i$$

where $\varphi_{i,t-1} = \exp(\mathbf{Z}'_{t-1}\Pi_i)$ and $\kappa_{i,t-1} = (\mathbf{Z}'_{t-1}\Theta_i)$. $Var(r_j)$, j=1 or 2, indicates that only the variance of the ADRs or of the underlying stocks is added to the respective mean equation. r_i are XLATADR, XLATUDR, XFTWRLD, which are the excess returns on the Latin American ADRs, the Latin American underlying stocks, the FT-Actuaries world index, and TWIFXR is the log-price differences of a trade-weighted index of the exchange rates of the top ten economies with the US dollar. **Z** is a vector of instruments including EUR01, TERM, and DEFALT which are the weekly one-month Eurodollar deposit rate, the US term premium, and the US default premium. The term premium is measured by the difference between the yield on the 10-year Treasury Notes and the 90-day Treasury Bill. The default premium is the spread between the yield on the Moody's Baa- and Aaa-rated bonds. MEXFXR, the log-price difference of the Mexican peso/dollar exchange rate, IFCLAR the return on the IFC Latin American regional index are local/regional instruments. All t-values in Panel A are based on a quasi-maximum likelihood estimation robust to non-normality in the residuals. All residual diagnostics are based on standardized residuals. LB(x) is the Ljung-Box chi-squared statistics for testing the null hypothesis of zero autocorrelation up to the xth lag. LM is the Lagrange multiplier test (chi-squared statistic and p-value) for ARCH in the residuals, with 8 degrees of freedom.

Panel A Conditional Mean

	XLATADR	XLATUDR[a]	XFTWRLD	TWIFXR
Π (Market Risk)				
Constant	4.137 (2.962)	-27.90 (-3.595)	66.72 (3.151)	-12.07 (-7.045)
XFTWRLD{1}	0.621 (1.499)	8.208 (6.548)	-74.77 (-2.663)	-1.895 (-2.953)
EUR01	-0.653 (-3.152)	-7.745 (-10.90)	-31.47 (-2.673)	-4.291 (-4.639)
TERM	0.726 (1.757)	-12.22 (-8.897)	-53.26 (-2.653)	1.976 (5.639)
DEFALT	-11.90 (-6.980)	75.07 (6.286)	-60.77 (-3.730)	12.61 (2.947)
IFCLAR{1}	0.560 (4.410)	3.566 (6.364)	-21.62 (-2.641)	-1.584 (-4.880)
MEXFXR{1}	0.526 (5.784)	3.604 (6.973)	-37.51 (-2.645)	0.900 (3.140)
Θ (Currency Risk)				
Constant	4.426 (1.720)	8.458 (2.199)	-6.287 (-3.123)	1.342 (4.421)
XFTWRLD{1}	-0.300 (-1.933)	0.175 (0.793)	-1.108 (-2.257)	0.097 (1.786)
EUR01	-0.963 (-3.038)	-1.981 (-4.197)	1.868 (7.772)	-0.400 (-6.441)
TERM	-4.100 (-4.252)	-3.986 (-4.633)	-3.095 (-5.296)	0.079 (1.654)
DEFALT	14.89 (3.470)	15.00 (2.699)	6.707 (2.578)	0.306 (1.274)
IFCLAR{1}	-0.183 (-1.185)	0.090 (0.625)	0.522 (2.338)	-0.057 (-0.984)
MEXFXR{1}	0.316 (1.835)	-0.040 (-0.183)	-2.231 (-5.499)	0.413 (8.705)
Intercept	-2.808 (-1.039)	-3.810 (-0.951)	-0.062 (-0.614)	-0.555 (-1.048)
Own Variance	0.158 (2.191)	0.300 (1.187)	-------	-------
Ψ (Global Instruments)				
XFTWRLD{1}	-0.035 (-0.196)	0.054 (0.408)	-0.445 (-2.307)	-0.198 (-1.894)
EUR01	-0.761 (-2.570)	-0.586 (-2.146)	0.454 (7.143)	0.345 (3.221)
TERM	-1.672 (-4.028)	-1.246 (-4.330)	-1.368 (-6.184)	-0.194 (-3.127)
DEFALT	11.32 (6.388)	9.288 (4.884)	1.565 (3.635)	-0.760 (-2.647)
(Regional Instruments)				
IFCLAR{1}	-0.094 (-1.776)	-0.084 (-1.404)	0.192 (2.460)	0.056 (1.027)
MEXFXR{1}	-0.356 (-2.378)	-0.238 (-1.803)	-0.870 (-5.122)	-0.522 (-10.57)
Conditional Variance[b]				
A_1	0.347 (5.879)	0.257 (3.900)	0.089 (2.720)	0.312 (9.291)
B_1	-0.658 (-16.92)	-0.808 (-33.18)	-0.185 (-1.852)	0.892 (50.53)

Continued next page.

Panel B Specification Tests

ALL MARKETS

H_0: Zero prices of market risk	- χ^2 (28)	2720.30 (0.000)
H_0: Constant price of market risk	- χ^2 (24)	1955.47 (0.000)
H_0: Zero prices of currency risk	- χ^2 (28)	1398.72 (0.000)
H_0: Constant price of currency risk	- χ^2 (24)	1122.91 (0.000)
H_0: Zero additional impact of all information variables	- χ^2 (24)	1391.90 (0.000)
H_0: Zero intercepts	- χ^2 (4)	56.07 (0.000)

LATIN AMERICAN MARKETS

H_0: Zero impact of local information variables on market risk	- χ^2 (4)	77.74 (0.000)
H_0: Zero impact of local information variables on currency risk	- χ^2 (4)	5.991 (0.200)
H_0: Zero additional impact of local information variables	- χ^2 (4)	7.363 (0.118)
H_0: Zero variance risk	- χ^2 (2)	9.369 (0.009)

	XLATADR	XLATUDR	XFTWRLD	TWIFXR
Avg. Prediction Error [t-value][c]	0.063 [0.018]	0.092 [0.030]	-0.005 [-0.000]	-0.039 [-0.033]

Panel C Robust Wald Tests of Integration of the Latin American Markets

H_0: Equal prices of market risks	- XLATADR and XLATUDR - χ^2 (7)	171.0 (0.000)
H_0: Equal prices of currency risks	- XLATADR and XLATUDR - χ^2 (7)	18.71 (0.009)
H_0: Equal additional predictability of information variables	- XLATADR and XLATUDR - χ^2 (6)	9.956 (0.127)
H_0: Equal prices of variance risk	- XLATADR and XLATUDR - χ^2 (1)	0.565 (0.452)
H_0: Equal prices of market risks	- XLATADR and XFTWRLD - χ^2 (7)	25.09 (0.001)
H_0: Equal prices of currency risks	- XLATADR and XFTWRLD - χ^2 (7)	208.6 (0.000)
H_0: Equal additional predictability of information variables	- XLATADR and XFTWRLD - χ^2 (6)	123.4 (0.000)
H_0: Equal prices of market risks	- XLATUDR and XFTWRLD - χ^2 (7)	194.2 (0.000)
H_0: Equal prices of currency risks	- XLATUDR and XFTWRLD - χ^2 (7)	146.3 (0.000)
H_0: Equal additional predictability of information variables	- XLATUDR and XFTWRLD - χ^2 (6)	116.0 (0.000)

Panel D Standardized Residual Diagnostics

	XLATADR	XLATUDR	XFTWRLD	TWIFXR
Skewness (p-value)	-0.232 (0.141)	-0.240 (0.128)	-0.357 (0.023)	0.289 (0.067)
Kurtosis (p-value)	0.048 (0.879)	0.405 (0.202)	0.099 (0.756)	0.759 (0.017)
Jarque-Bera (p-value)	2.174 (0.337)	3.944 (0.139)	5.194 (0.075)	9.089 (0.011)
Autocorrelation (Level)				
LB (4) (p-value)	4.011 (0.405)	8.391 (0.078)	7.146 (0.128)	7.057 (0.133)
LB (8) (p-value)	6.192 (0.626)	11.64 (0.168)	7.744 (0.459)	11.84 (0.158)
Autocorrelation (Squared)				
LB (4) (p-value)	1.829 (0.767)	5.429 (0.246)	5.934 (0.204)	3.244 (0.518)
LB (8) (p-value)	6.533 (0.588)	15.11 (0.057)	9.688 (0.288)	7.351 (0.499)
LM (8) - (ARCH in Residuals)	5.584 (0.694)	11.96 (0.153)	11.10 (0.196)	8.886 (0.352)
Wald: Constant variance - χ^2 (8)	11505.3 (0.000)			
Loglikelihood	-868.234			

a) An AR(1) term with coefficient (t-value) of 0.068 (1.968) was included in this equation.
b) A non-diagonal version of the model caused misspecification and convergence problems.
c) Based on the unstandardized residuals from the conditional mean.

V. Summary and Conclusions

This paper studies the integration of the Latin American markets during the period January 1992 to December 1996, using ADRs and their underlying stocks. It also characterizes the volatility of these assets and tests for time-variation in their prices of world market and currency risks. The test of integration is based on the null hypothesis that if the markets are integrated, then the prices of risks of the ADRs and their underlying stocks are the same. There are several advantages to this approach. First, it is a direct test of market integration, relying on the strict definition of integration. Second, the use of depositary receipts and their underlying stocks avoids the joint-hypothesis problem attendant with the use of asset pricing models to test for integration. Third, the test as applied allows us to make inferences about the cause of any observed segmentation. The methodology and econometric approach, therefore, provide a test of the robustness of other tests of emerging markets integration.

Main Findings. The mean and volatility of the Latin American ADRs and their underlying stocks are predictable. While the means are predicted by local and global instruments, the GARCH parameters are sufficient to reflect the volatility of these assets. There is no additional gain from including global exogenous variables nor to modeling an asymmetric response to market news in the volatility of these assets. The duration of volatility shocks (half-lives) of the ADRs and their underlying stocks are about one week, about a third of that of the world market.

The Latin American ADRs and their underlying stocks are priced by the specification of the International CAPM which includes the conditional covariances with the world market and the world currency index as risk factors. This in itself suggests that the markets are not completely segmented.

The Latin American markets are only partially integrated with the world capital markets. This is despite the substantial and successful efforts at market reforms and liberalization pursued by regional governments in the period 1989 to 1992 and the economic integration of one of the region's largest market (Mexico) with North America. Furthermore, the evidence suggests that the vestiges of both direct (legal) and indirect barriers to international investments continue to play a role in the segmentation of Latin America. These might include restrictions on the ownership of bank-related equity by foreigners in the Mexican market, possible information asymmetry affecting investors in the region's ADRs, burdensome transaction costs impairing the efficacy of arbitrage related transactions, and other restrictions. It is not clear what is the extent of the segmentation arising from (foreign) investor attitudes.

Chapter 9. Conclusion

Scope of the Thesis. This thesis has two sections. In the first I review the theory and empirical work related to market integration and international asset pricing. I also survey the econometric techniques which are employed in the empirical essays of the thesis. These include ARCH models and Mean-Variance Spanning. In the second section three related empirical topics are then examined using the American Depositary Receipts (ADRs) and country funds of Argentina, Chile, and Mexico. I investigate intra- and inter-market transmission of returns and volatility, international portfolio diversification, and empirical international asset pricing. Market integration is the issue which connects the various sections of the thesis.

Summary of Empirical Work. The *first* empirical essay (Chapter 6) investigates the transmission of mean and volatility between the Mexican market, the Mexican ADRs, and the US market, between the Mexican ADRs and their underlying stocks, and between the Mexican ADRs and the ADRs from the rest of Latin America. This is done in a framework which allows us to make inferences about the integration of the Mexican market. If the Mexican market is integrated, then the ADRs and their underlying stocks, both of which are based on the same cash flows, will yield the same expected dollar returns, regardless of the fact that they trade in different markets. This being the case, both assets should also impound relevant market information at the same rate, and thus there should be no lagged spillovers (called reverse spillovers) between them. Furthermore, as the ADRs become integrated with the international capital markets they should behave like the stocks of the US market, reacting more to global market news rather than to home-market information.

First, using a trivariate GARCH framework applied to the returns of the ADRs, the Mexican index, and the S&P 500 index, I find that the mean and volatility of the ADRs are predicted more by the Mexican index. This suggests that they behave more like Mexican rather than US securities. Though the impulse response functions from the vector autoregression (VAR) model are not significant they offer some corroboration for the above result. Second, a bivariate GARCH specification is used to investigate mean and volatility spillover between the ADRs and their underlying stocks. I find significant reverse spillovers. When the latter test was redone to account for the possible impact of foreign exchange rate changes the results did not change significantly, but it appears that the volatility of the peso/dollar exchange rate causes an underestimation of the volatility of the equity market. I also look at the issue of regional contagion between the Mexican ADRs and the ADRs of Argentina and Chile. There is no contagion and it appears that only in periods of heightened volatility is there any co-movement of regional volatility.

The existence of lagged mean and volatility spillovers between the ADRs and their underlying stocks is inconsistent with integrated markets, indicating that the Mexican market is still mildly segmented. This is supported by the fact that the ADRs are still predominantly influenced by the home, rather than by the host market.

The development and use of Mean-Variance Spanning, including its generalization from the original CAPM-based model to one consistent with the Latent Variables asset pricing model, is reviewed in Chapter 5. The *second* empirical essay (Chapter 7) employs conditional and unconditional Mean-Variance Spanning tests which are estimated with the generalized method of moments (GMM). It examines, from the standpoint of a US investor, the impact of the Mexican peso crash on the diversification from investing in Latin American ADRs and country funds. Its specific objective is to determine if investing in the Latin American assets provided diversification for the US investor who held the S&P 500 and other assets and to investigate the effect of the crash on these benefits.

First, the non-Mexican ADRs provided significant diversification to the US investor holding domestic assets in the period before the peso crash. Following the crash, the model is unable to detect any diversification from investing in the non-Mexican ADRs when the US investor holds both the S&P 500 and the risk-free asset. Second, the Mexican ADRs provided no diversification during the period under review. Third, the country funds of the Latin American markets provided diversification before but not after the crash. Fourth, I find that as the investor expanded her investment to include the domestic risk-free asset, the diversification from investing in Latin American assets declined. When the S&P 500 was combined with a portfolio of ADRs from the developed markets, this investment spanned all Latin American assets. Finally, the results cannot be attributed to a common factor affecting all emerging markets' assets as a portfolio of mainly Asian ADRs provided diversification after the crash, and the

Thai country fund provided no diversification benefits in any period regardless of the benchmark.

I then use an augmented version of the bivariate, constant-correlation GARCH model to show that there was an increase in the conditional correlation between the non-Mexican ADRs and the S&P 500 and between the regional country fund and the S&P 500 after the crash. The significant increase in correlation between these markets could help to explain a part of the lack of diversification from the Latin American assets in the post-crash period. Similarly, the changing relation between the spanning assets and the information variables suggests that the investor's portfolio composition was changing with time and this could also have affected the diversification provided by the Latin American assets.

Further analyses indicate that the non-Mexican ADRs listed after the crash failed to provide diversification for the US investor. Those ADRs which were listed prior to the crash did not benefit the investor in the post-crash period either. If US investors considered new listings as a signal that the region's corporate managers were anticipating poor future performance, given the shock of the peso crash, then the poor post-crash performance may be reflecting investors' reaction. There was no post-listing under-performance by the ADRs that were listed in the period before the crash.

In two literature review chapters I define integration, survey tests of integration, summarize the empirical results, and explore various international asset pricing models. The *third* empirical essay (Chapter 8) combines this knowledge to test the integration of the Latin American markets, while achieving several related objectives on the way. In the first section of the essay I study the volatility of the Latin American ADRs and their underlying stocks. I assess the predictability and persistence of their volatility and investigate if global instrumental variables have incremental predictive information for the volatility of the assets. I also test if there is asymmetric response in volatility to events such as bad news in the equity market.

I find that the mean and volatility of the returns on the Latin American markets are predictable. This is important for the main objective of the Chapter. If the markets are not predictable, then the application of a model which imposes time-variation on the prices of risks would be inappropriate. While the mean of the returns are predicted by global instruments, the GARCH parameters are sufficient to reflect the volatility of these assets. There is no additional gain to including exogenous global variables nor to modeling an asymmetric response to market news in the volatility of the assets. The duration of volatility shocks (half-lives) of the ADRs and their underlying stocks are about one week, less than a third of that of the world market. The fact that the Latin American assets do not display significant asymmetry in their volatility may be related to the fact that these ADR firms are likely to be financed more by equity than by debt.

In the second section I test the integration of the Latin American markets. I first explore the pricing of the Latin American assets using a specification of the International CAPM in which the risk factors are the conditional covariance with the world market portfolio and the conditional covariance with a trade-weighted index of exchange rates against the dollar. This model is applied to a system of equations including the ADRs, their underlying stocks, the world portfolio, and the world exchange rate index while assuming that the prices of risks are the same across all markets. There is no evidence of model misspecification, suggesting that the Latin American assets are priced by international factors both in the case where the prices of risks are constant and when they are predicted by a set of global instruments.

I then test for integration by specifying a system of equations in which the prices of risks are not restricted to be equal across markets for the ADRs, their underlying stocks, the world portfolio, and the world exchange rate index. Next, I test the null hypothesis that the prices of risks for the ADRs and their underlying stocks are equal.

Finally, to check for the robustness of the segmentation indicated by the above results, I specify a model in which, in addition to the priced risk factors, I also added an intercept for each market, included the variances of the Latin American assets, included regional instruments in the set of variables predicting the prices of risks, and allowed the instruments to be exogenous variables in each equation.

There are several contributions of this test to the literature on market integration. First, the motivation of this test is to rely on the strict definition of integration. Second, the application of the asset pricing model to the ADRs and their underlying stocks overcomes the joint-hypothesis problem associated with testing market integration using an asset pricing model. This is so since a rejection of the null hypothesis of integration cannot be based on the rejection of the asset pricing model by the data since both the ADRs and their underlying stocks would reject the model equally.

Hence, the prices of risks associated with each asset would be the same even if the model is inappropriate. Third, by comparing the prices of risks of the ADRs and their underlying stocks, respectively, to the prices of risks of the world market we can determine the class of barriers that are causing any segmentation.

I find that the Latin American markets are only partially integrated with the world capital markets. First, the null hypothesis that the prices of risks for the ADRs and their underlying stocks are equal is rejected. Second, the null hypothesis of equal prices between the ADRs and their underlying stocks and the world portfolio is also rejected. Finally, the regional instruments marginally predict the prices of risks, and the variance of the Latin American ADRs is priced. My results corroborate some previous findings but are interesting in the sense that no previous test used ADRs nor restricted their attention to the period following the significant market and economic reforms pursued by regional governments in the period 1989 to 1992. Furthermore, while we cannot rule out the effects of investor attitudes and irrationality as a cause of segmentation, the rejection of equality of the prices of risks between the world portfolio and the ADRs and underlying stocks suggest that legal/direct barriers to international investments remain in force.

Further Research. This thesis has systematically investigated the volatility, diversification benefits, and (asset) pricing of the emerging markets. The connective issue is the integration of Latin America. All three empirical chapters fall within a framework which allows some inferences about integration. There are other issues which will arise from the work conducted here but which are beyond the scope of the present efforts. Some of this further work will be done in the future. For instance, I have already started to reformulate the Mean-Variance Spanning test so that it is more economically intuitive, more consistent with other measures of risk-to-reward employed in finance, and at the same time allows estimation using other techniques than the generalized method of moments (GMM) without losing the appeal of conditioning and heteroscedastic-consistency.

Within the thesis, additional tests could have been done in some areas. For instance, a measure of liquidity (such as number of transactions) could have been used as an exogenous factor in the tests of spillover since there is evidence that the underlying stocks trade less frequently than their ADRs. Data limitations, especially for the domestic (Mexican) market, prevented this. Additionally, the tests of Mean-Variance Spanning could be subjected to further robustness tests such as industry- or size-based portfolios of US equities and weekly time intervals. The use of other indices than the S&P 500 is an attempt to mitigate the first shortcoming. Given the short time series of the ADRs and country funds that are available and the fact that the GMM test is an asymptotic test, it was decided not to use longer time intervals, which would necessarily reduce the number of observations. This could lead to a rejection of the null hypothesis of spanning purely on account of a breach of the assumption of a large sample size. Since there are no significant signs of model misspecification for the test of integration it is not clear that additional benefits could have been derived by using an alternate asset pricing model. If that were the case, however, the first candidate would be a multi-factor model in which the factors are estimated by, say, principal components analysis from a large group of all ADRs.

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APPENDIX

Appendix A. Overview of Investment Activities in the Emerging Markets

The importance of the emerging markets in the world capital markets is underscored by the fact that in recent years the emerging markets have been attracting large inflows of foreign capital to their equities markets. It is estimated that between 1990 and 1996, of the $230 billion of foreign capital injected into the emerging stock markets $53 billion was invested in ADRs and about $115 billion in country funds. In 1996, 144 of the 556 ADRs issued by 42 countries raised about $9 billion for the emerging markets, compared with $35.8 billion raised domestically. At the end of 1996 the total market capitalization of the emerging markets stood at more than $2.1 trillion, over 10% of total world capitalization. Latin America attracted $16.5 billion of the $45.7 billion of foreign capital invested in the emerging markets in 1996, more than the $12.9 billion flowing to East Asia and the Pacific (IFC (1997)).

The Latin American region offers a range of investment vehicles to international investors, including over 65 listed ADRs and more than 140 in the OTC and other markets. Among the emerging markets, Mexico dominates the ADRs market with a program that is exceeded only by those of Australia, Canada, Japan, South Africa, and the UK During 1995, the listed ADRs of Argentina, Chile, and Mexico accounted for just under 40% of the total share trading volume and 30% of the dollar trading volume of all listed ADRs. There are also more than twenty country and regional funds from Latin America. The region is also the largest market for Brady and other sovereign bonds and corporate debt among the emerging economies and Mexico is used as a benchmark in the pricing of emerging markets' fixed income securities (IMF (1995)). The Latin American market also lists several derivative products in the US, allowing investors to diversify their portfolios and to manage their exposure. There are options on ADRs, futures and options on the Mexican peso and Brazilian real, and a Mexican index futures.

Appendix B. Major Policy Changes in the Emerging Markets

Country	Date	Policy Change
Latin America		
Argentina	06/1980	Foreign Portfolio Investments (FPIs) restrictions reduced
Brazil	06/1990	Liberalization of capital repatriation and inflows
Chile	01/1988	Repatriation of dividends liberalized
Colombia	12/1989	Reduced restrictions on FPIs and foreign direct investments (FDIs)
"	12/1991	Lifted restrictions on capital repatriation
Mexico	05/1989	Liberalization of FDIs
"	-/1992	Removed restrictions on FPIs in most sectors
Venezuela	01/1990	FPIs and FDIs liberalized
Asia and the Middle East		
India	05/1990	Streamlined approval for FDIs from firms with 40% equity input
"	- /1992	Repatriation of dividends allowed
Jordan	01/1987	Capital repatriation liberalized
Korea	08/1981	Liberalization of capital flows for FDIs
"	01/1992	Liberalization of capital flows for FPIs
Malaysia	11/1986	Liberalization of FDIs and inflows from FPIs
Pakistan	- /1990	Liberalization of dividend and capital repatriation
Philippines	- /1988	Liberalization of dividend and capital repatriation
"	- /1992	Further liberalization
Taiwan	02/1991	Allowed FPIs
Thailand	- /1988	Liberalization of dividend and capital repatriation
Europe		
Portugal	- /1988	Liberalization of dividend repatriation
"	1989-90	Liberalization of outward investments by citizens
Turkey	02/1990	Culmination of liberalization process

Source: Park and Agtmael (1993), Bekaert (1995), Levine and Zervos (1996), IFC (various issues).

Appendix C. Latin American Exchange-Listed ADRs

ARGENTINA (9)	Local Code	PERM NO.	CUSIP	Exchange	RATIO	DRs issued	Listing Date
Banco de Galicia y Buenos Aires "B"	BGALY	79316	59538207	NAS	1:04	3,210,000	930611
Banco Frances del Rio de la Plata Common	BFR	79895	59591107	NYSE	1:03	5,594,222	931123
Buenos Aires Embotelladora "B" Shares	BAE	79208	119424208	NYSE	1:02	1,650,000	930504
IRSA Common Shares	IRS	81127	450047204	NYSE	1:10	555,515	941221
Metrogas S.A.	MGS	81062	591673207	NYSE	1:10	5,610,000	941123
Telecom Argentina Stet-France Telecom SA	TEO	81133	879273209	NYSE	1:10	6,423,800	941212
Telefonica de Argentina S.A. GDR	TAR	80409	879378206	NYSE	1:10	14,560,000	911223
Transportadora de Gas del Sur, S.A.	TGS	81067	893870204	NYSE	1:05	20,257,338	941118
YPF Sociedad Anonima "D" Shares	YPF	79362	984245100	NYSE	1:01	125,000,000	930628
CHILE (19)							
AFP Provida S.A	PVD	81050	00709P108	NYSE	1:01	3,600,000	941116
Banco de A. Edwards	AED	82631	59504100	NYSE	1:165	4,140,000	951103
Banco O'Higgins		80590	59629105	NYSE	2:06	4,956,771	940526
Banco Osorno y La Union, S.A.	BSB	81054	59631101	NYSE	1:220	8,300,000	941104
Chilgener S.A.	CHR	80712	168894103	NYSE	1:04	2,960,584	940719
Compania Cervecerias Unides S.A.	CCUUY	77928	204429104	NAS	1:05	4,520,582	920924
Compania De Telefonos De Chile	CTC	76242	204449201	NYSE	1:17	6,500,000	900720
Cristalerias de Chile, S.A.	CGW	80173	226714103	NYSE	1:03	4,020,000	940125
Embotelladora Andina, S.A.	AKO	80716	29081P105	NYSE	1:06	7,076,700	940707
Empresas TelexChile Common Shares	TL	81031	29245D105	NYSE	1:02	4,675,000	941014
Empresa Nacional de Electricidad-ENDESA	EOC	80717	29244T101	NYSE	1:30	2,550,000	940727
Empresa Nacional De Electric S A		75290					< 9201
Enersis S.A.	ENI	79767	29274F104	NYSE	1:50	3,510,670	931020
Laborotorio Chile S.A. "B"	LBC	80690	50540H104	NYSE	1:20	1,825,000	940628
Madeco Common Shares	MAD	79234	556304103	NYSE	1:10	4,331,250	930528
Maderas y Sinteticos Common Shares	MYS	79339	556465102	NYSE	1:30	4,165,625	930617
Santa Isabel	ISA	81779	802233106	NYSE	1:15	4,369,446	950727
Sociedad Quimica y Minera de Chile "B"	SQM	79663	833635105	NYSE	1:10	1,702,754	930921
Vina Concha y Toro Common Shares	VCO	81049	927191106	NYSE	1:50	2,840,000	941014
MEXICO (32)							
Banpais "L" Shares	BPS	80676	66700105	NYSE	1:06	10,270,000	940630
Bufete Industrial, S.A.	GBI	79896	11942H100	NYSE	1:03	4,166,680	931103
Coca-Cola Femsa "L" Shares	KOF	79644	191241108	NYSE	1:10	7,384,100	930913
Consorcio G Grupo Dina SA de CV	DIN	80780	210306106	NYSE	1:04	10,821,909	940816
Consorcio G Grupo Dina S A De CV		79064					930331
Desc, S.A. de C.V. Series C	DES	80714	250309101	NYSE	1:04	2,300,000	940713
Empresas ICA "A" CPO	ICA	77545	292448107	NYSE	1:01	19,205,000	920408
Empresas la Moderna "A" CPO	ELM	80197	292449105	NYSE	1:04	8,533,000	940201
Grupo Casa Autrey	ATY	80087	40048P104	NYSE	1:04	3,750,000	931215
Grupo Elektra CPO	EKT	81125	40050A102	NYSE	1:02		941205
Grupo Embotellador de Mexico,SA de CV	GEM	80392	40048J306	NYSE	1:02	3,850,000	940406
Grupo Financiero SERFIN	SFN	80088	40049A106	NYSE	1:04	12,650,000	931208
Grupo Industrial Durango "A" CPO	GID	80721	40048E109	NYSE	1:02	6,181,600	940714
Grupo Industrial Maseca S.A. de C.V.	MSK	80597	400488409	NYSE	1:15	3,415,500	940518
Grupo Iusacell Series "D" Shares	CELD	80686	40049W207	NYSE	1:10	1,714,626	940614
Grupo Iusacell Series "L" Shares	CEL	80687	40049W306	NYSE	1:10	4,000,794	940614
Grupo Mexicano de Desarrollo "B" Shares	GMDB	80085	40048G104	NYSE	1:01	861,917	931215
Grupo Mexicano de desarrollo "L" Shares	GMD	80086	40048G103	NYSE	1:01	983,354	931215
Grupo Radio Centro, S.A. de C.V.	RC	79436	40049C102	NYSE	1:09	3,040,000	930709
Grupo Sidek "B" Shares	SDKB	80722	400490306	NYSE	1:04	6,045,000	940712
Grupo Sidek "L" Shares	SDK	81037	400490108	NYSE	1:04		941026

Grupo Simec "B" Shares	SIM	79442	400491106	AMEX	1:20	2,347,837	930630
Grupo Televisa, S.A. GDR	TV	80089	40049J206	NYSE	1:02	13,670,000	911216
Grupo Tribasa Common Shares	GTR	79655	40049F105	NYSE	1:02	13,600,000	930922
Internacional de Ceramica "D" Shares	ICM	81130	458847506	NYSE	1:05	1,044,000	941215
Servicios Financieros Quadrum S.A.	QDRMY	79433	05944R108	NAS	1:01	3,693,880	930728
Telefonos de Mexico "A" Shares	TFONY	76636	879403400	NAS	1:01	40,000,000	910513
Telefonos de Mexico S.A. de C.V. Ser L	TMX	75142	879403780	NYSE	1:20	22,150,000	920518
Transportacion Maritima Mexicana "A"	TMMA	77646	893868307	NYSE	1:01	2,045,000	920610
Transportacion Maritima Mexicana "L"	TMM	77647	893868208	NYSE	1:01		920610
Tubos de Acero de Mexico, S.A.	TAM	40299	898592506	AMEX	1:01	3,920,000	801029
Vitro Sociedad de C.V.	VTO	77560	928502301	NYSE	1:01	6,500,000	911119

Source: BNY(1996a, b)

Appendix D. Method Used To Create a Value-Weighted Index

This index is a Value-Weighted Index based on the Chained Paasche Method.

$\mathbf{X_t = (M_t / B_t)*100}$ and $B_t = B_{t-1}*(M_t/MA_{t-1})$

where

X_t = Price Index at time t
B_t = Base Value of Index at time t
M_t = Sum($p_{it}*n_{it}$) = Market Capitalization of n components stocks at time t
MA_t = Adjusted Market Capitalization

If t=1, called 'Base Date', then $X_t = 100$ as $M_1 = B_1$

There are generally two types of adjustments to market capitalization:

$MA_t=(M_t - I_t - R_t - N_t + Q_{t-1})$

or

$MA_t= (M_t - I_t - R_t - N_t + Q_{t-1} + D_t + V_t)$.

These include stock dividends (bonus), rights issues, new issues of stock for a listed firm, new listings of firms, and stock de-listings. If the index is a *Total Return Index*, then include payment of cash dividends and stock dividends implicit in rights issues. Note that for value-weighted indices, stock splits have no impact on the index as the market value is not affected.

$p_{i,t}$ = Closing Price of stock i in period t
$n_{i,t}$ = Number of shares issued and outstanding for firm i at end of period t
I_t = Market value of new (additional) issues of shares for a listed firm

A listed firm canceling shares would be treated as a negative new issue. New stocks from converting other securities, (e.g., bonds) are new issues.

R_t = Market value of rights issued at time t, (market price per share*number of shares)
N_t = Market Value of new stocks (firms) listed at time t
Q_t = Market value of previously-listed stocks de-listed in time t
D_t = Total cash dividend paid at time t (Dividend per share*number of eligible shares)
V_t = Total Implied stock dividend in rights issues

Total Implied Dividend in rights issue =
(No. of shares in rights issue)*(price of rights issue - last market price of stock prior to rights issue)

Therefore, rights issues above market price reduce total return.

Source: IFC (1997)

Appendix E. A Synopsis of the Mexican Peso Crisis of December 1994

Mexico's financial crisis resulted from a number of complex financial, economic, and political factors during 1994 that forced monetary and fiscal policies out of line with its exchange rate policy. Since its financial inflow was highly exposed to the fickleness of foreign portfolio investments, confidence in the political and economic systems is of paramount importance. This was shaken in Mexico in 1994 following the assassination of a Mexican presidential candidate on March 23. As the country was experiencing a decline in foreign currency reserves the US government decided on March 24 to provide a temporary short-term credit facility of $6 billion. Within just over a month of this the facility had been depleted as reserves fell by $7.1 billion, from $24.4 billion at the end of March to $17.3 billion at the end of April. In response, the government devalued the peso by less than 1 percent against the dollar in keeping with its limit under the exchange rate band arrangement then in force. An earlier depreciation of 7 percent had occurred in February 1994. Further assistance of just under $7b was announced by its North American Free Trade Agreement (NAFTA) partners in April.

Further political complications continued in 1994. There were the flare up of the Chiapas rebellion in November and early December and the assassination of the ruling party's Secretary in September 1994. On the economic side, the government announced on December 9 that it expected the current account deficit to increase in 1995 but had no intention to change its exchange rate policy. Portfolio investors increased their redemption of Mexican securities leading to a further $10b drop in reserves. The government's local debt continued to increase with over $30b falling due in 1995. On December 20, the peso/dollar exchange rate band was widened, resulting effectively in a 15 percent devaluation, this without the requisite fiscal or monetary policy changes. In just a day's foreign exchange trading (December 21), more than $4b of foreign reserves were lost. The following day, December 22, Mexico was forced to freely float its currency despite the previous statements by the authorities that this was not part of their policy.

The poor policy mix and loss of investors' confidence leading to continued redemption of government securities meant the pressure on the peso continued into 1995. The US provided up to $20b in loans and security guarantees to Mexico with the IMF pledging another $17.8b over 18 months. These actions stemmed the tide a bit and restored some semblance of stability but the peso continued to be weak even though by early 1997 the stock market had made a sort of recovery.

SOURCE: Report to the Chairman, Committee on Banking and Financial Services: House of Representatives, February 1996, entitled MEXICO'S FINANCIAL CRISIS - ORIGINS, AWARENESS, ASSISTANCE, AND INITIAL EFFORTS TO RECOVER (GAO/GGD-96-56), available from this source or from the Internet under Mexico's web page.

$$
\begin{bmatrix} H_{11} & H_{12} & H_{13} \\ 0 & H_{22} & H_{23} \\ 0 & 0 & H_{33} \end{bmatrix}
=
\begin{bmatrix} [c_{11}^2] & [c_{11}c_{12}] & [c_{11}c_{13}] \\ 0 & [c_{12}^2 + c_{22}^2] & [c_{12}c_{13} + c_{22}c_{23}] \\ 0 & 0 & [c_{13}^2 + c_{23}^2 + c_{33}^2] \end{bmatrix} +
$$

$$
\begin{bmatrix}
\begin{bmatrix} a_{11}^2 h_{11} + a_{21}^2 h_{22} + a_{31}^2 h_{33} \\ + 2(a_{21}a_{11})h_{12} + 2(a_{31}a_{11})h_{13} \\ + 2(a_{31}a_{21})h_{23} \end{bmatrix} &
\begin{bmatrix} a_{11}a_{12}h_{11} + a_{21}a_{22}h_{22} + a_{31}a_{32}h_{33} + \\ (a_{21}a_{12} + a_{11}a_{22})h_{12} + (a_{31}a_{12} + a_{11}a_{32})h_{13} + \\ (a_{31}a_{22} + a_{21}a_{32})h_{23} \end{bmatrix} &
\begin{bmatrix} a_{11}a_{13}h_{11} + a_{21}a_{23}h_{22} + a_{31}a_{33}h_{33} + \\ (a_{21}a_{13} + a_{11}a_{23})h_{12} + (a_{31}a_{13} + a_{11}a_{33})h_{13} + \\ (a_{31}a_{23} + a_{21}a_{33})h_{23} \end{bmatrix} \\
0 &
\begin{bmatrix} a_{12}^2 h_{11} + a_{22}^2 h_{22} + a_{32}^2 h_{33} + 2(a_{22}a_{12})h_{12} + \\ 2(a_{32}a_{12})h_{13} + 2(a_{32}a_{22})h_{23} \end{bmatrix} &
\begin{bmatrix} a_{12}a_{13}h_{11} + a_{22}a_{23}h_{22} + a_{32}a_{33}h_{33} + \\ (a_{22}a_{13} + a_{12}a_{23})h_{12} + (a_{32}a_{13} + a_{12}a_{33})h_{13} + \\ (a_{32}a_{23} + a_{22}a_{33})h_{23} \end{bmatrix} \\
0 & 0 &
\begin{bmatrix} a_{13}^2 h_{11} + a_{23}^2 h_{22} + a_{33}^2 h_{33} + 2(a_{23}a_{13})h_{12} \\ 2(a_{33}a_{13})h_{13} + 2(a_{33}a_{23})h_{23} \end{bmatrix}
\end{bmatrix} +
$$

$$
\begin{bmatrix}
\begin{bmatrix} b_{11}^2 e_1^2 + b_{21}^2 e_2^2 + b_{31}^2 e_3^2 \\ + 2(b_{21}b_{11})e_1e_2 + 2(b_{31}b_{11})e_1e_3 \\ + 2(b_{31}b_{21})e_2e_3 \end{bmatrix} &
\begin{bmatrix} b_{11}b_{12}e_1^2 + b_{21}b_{22}e_2^2 + b_{31}b_{32}e_3^2 \\ + (b_{21}b_{12} + b_{11}b_{22})e_1e_2 + (b_{31}b_{12} + b_{11}b_{32})e_1e_3 \\ + (b_{31}b_{22} + b_{21}b_{32})e_2e_3 \end{bmatrix} &
\begin{bmatrix} b_{11}b_{13}e_1^2 + b_{21}b_{23}e_2^2 + b_{31}b_{33}e_3^2 \\ + (b_{21}b_{13} + b_{11}b_{23})e_1e_2 + (b_{31}b_{13} + b_{11}b_{33})e_1e_3 \\ + (b_{31}b_{23} + b_{21}b_{33})e_2e_3 \end{bmatrix} \\
0 &
\begin{bmatrix} b_{12}^2 e_1^2 + b_{22}^2 e_2^2 + b_{32}^2 e_3^2 + 2(b_{22}b_{12})e_1e_2 + \\ 2(b_{32}b_{12})e_1e_3 + 2(b_{32}b_{22})e_2e_3 \end{bmatrix} &
\begin{bmatrix} b_{12}b_{13}e_1^2 + b_{22}b_{23}e_2^2 + b_{32}b_{33}e_3^2 \\ + (b_{22}b_{13} + b_{12}b_{23})e_1e_2 + (b_{32}b_{13} + b_{12}b_{33})e_1e_3 \\ + (b_{32}b_{23} + b_{22}b_{33})e_2e_3 \end{bmatrix} \\
0 & 0 &
\begin{bmatrix} b_{13}^2 e_1^2 + b_{23}^2 e_2^2 + b_{33}^2 e_3^2 + 2(b_{23}b_{13})e_1e_2 + \\ 2(b_{33}b_{13})e_1e_3 + 2(b_{33}b_{23})e_2e_3 \end{bmatrix}
\end{bmatrix} +
$$

$$
\begin{bmatrix} [W_{11}^2] & [W_{11}W_{12}] & [W_{11}W_{13}] \\ 0 & [W_{12}^2 + W_{22}^2] & [W_{12}W_{13} + W_{22}W_{23}] \\ 0 & 0 & [W_{13}^2 + W_{23}^2 + W_{33}^2] \end{bmatrix} \mathrm{Wknd} +
\begin{bmatrix} [L_{11}^2] & [L_{11}L_{12}] & [L_{11}L_{13}] \\ 0 & [L_{12}^2 + L_{22}^2] & [L_{12}L_{13} + L_{22}L_{23}] \\ 0 & 0 & [L_{13}^2 + L_{23}^2 + L_{33}^2] \end{bmatrix} \mathrm{Hol} +
\begin{bmatrix} [K_{11}^2] & [K_{11}K_{12}] & [K_{11}K_{13}] \\ 0 & [K_{12}^2 + K_{22}^2] & [K_{12}K_{13} + K_{22}K_{23}] \\ 0 & 0 & [K_{13}^2 + K_{23}^2 + K_{33}^2] \end{bmatrix} \mathrm{Crash}
$$

Appendix F: Trivariate GARCH Model - All $\mathbf{H}_{ij}$ and dummy variables are measured at time t; h_{ij} and e_i are measured at t-1.