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Dynamic Daily Returns Among Latin American and Other Major World Stock Markets

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Abstract

Vector Auto Regression (VAR) models are used to trace the dynamic linkages across daily returns of national stock market indices of Latin America, and among the Latin American and major world stock market indicies. The Latin American indices include: Argentina, Brazil, Chile, and Mexico. The major world stock market indices include: the US; the world excluding the US; United Kingdom; Japan; Germany; France; and Canada. Although most of the impulse responses die out very quickly, it is still possible to trace the dynamic linkages among markets. The dynamic linkages among the Latin American markets and among the Latin American and major world stock markets are found to be relatively small. The conclusion is that although markets are efficient and cleared out in a few trading days, there are dynamic linkages that can be explored and exploited to the benefit of the diversified international investor.

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1 INTRODUCTION

This paper studies the dynamic linkages across national stock indicies of the newly emerging markets of South America. The late 1980's saw a gradual increase in international investment in the emerging markets of the newly industrialized countries in Latin America; in countries like Mexico, Brazil, Argentina, and Chile.[1] These newly emerging infant stock markets have been profitable for some daring investors. Yet, many market analysts have pointed out that such markets are somewhat of an anomaly in that they tend to be characterized by thin and narrow markets driven by poorly informed individuals rather than by fundamentals.[2]

One of the prominent examples that typify this new type of market is the Mexican stock market. Mexico, after six years of hard won stability, has lost in December 1994 about 36 percent of its stock index value in US dollars (and 50.6 percent in dollar terms in the year 1994) causing the Brazilian stock index to plunge by 16.4 percent since the Mexican currency crisis started. Despite this example, we cannot conclude that investment in the emerging stock markets is, as a whole, more risky than those in developed countries, given their expected returns. What it does suggest, is that the international investor would do better to diversify rather than concentrate his investments in a particular emerging market that is currently yielding high returns. The rationale behind global diversification is that stock markets are not highly correlated and consequently do not move in lock step with one another. Thus, a portfolio with a broad global mix can pay a higher return, than, say, the U.S. stock market alone, while reducing overall risk.

Moreover, U.S. investors are increasingly aware of the opportunities for investing in foreign exchanges.[3] Global diversification has generally paid well; in a ten year period ending in October, 1994, the U.S. portion of Morgan Stanley Capital International's world index was up by 296 percent, (with dividends

[1] This trend for increased international investment is also occurring in the newly developing markets of East and South Asia (Korea, Philippines, Taiwan and India, Indonesia, Thailand), in Europe (Greece, Portugal, Turkey) and in Africa (Nigeria and Zimbabwe).

[2] In fact, the International Finance Corporation (IFC), which help countries to develop their stock markets, has attempted to establish regulatory criteria for these stock markets. Of the emerging markets, only the countries of Brazil, Chile, Mexico, India, South Korea, and the Philippines have accounting standards, according to the IFC, that are acceptable internationally.

[3] In 1993 U.S. invested the net purchases of $67.8 billion in foreign exchanges. This figure was more than double what U.S. investors bought in each of the two preceding years and more than seven times the 1990 level.

reinvested but before subtracting withholding taxes), while Morgan Stanley's 20-stock-market Europe-Australia-Far-East (EAFE) Index was up 455 percent! Its world stock index climbed 345 percent.

There are some that claim that the logic behind international diversification may not hold in the future.[4] Expanding links between national economies and increasing intra-regional trade, combined with the explosive growth in cross-border portfolio investment, could create a world in which stock markets are synchronized, marching to the beat of the same drummer. Moreover, the experts directing those funds are all increasingly using the same information or have access to those same sources of information. Given the proliferation of similar data bases or similar sources of information in the investment world, the argument goes, there will undoubtedly be a convergence in the decision-making process. Another argument for the convergence of national stock markets is that many stock markets are becoming more accessible through deregulation, including an easing of rules on foreign investment. Additionally, the trend for increased privatization of government-owned industries extends the list of blue-chip opportunities for investors interested in markets like Mexico, Chile, Brazil and Argentina. These developments mean that the prices of foreign stocks are being influenced more and more by U.S. investor sentiment.[5] Furthermore, the emergence of regional economic blocs like the European Community, the North American Free Trade Agreement and nascent groupings in Asia and Latin America means that national economies - including stock markets - inevitably will move more in tandem. Regional integration is on the political agenda in Latin America in the 1990s. This stands in contrast to the 1960s, when regional economic integration was linked to state planning and managed trade rather than free trade and less government intervention.[6]

One crucial question is the role of the United States as the one major developed country in the region since the trade with Canada is generally small. Countries like Mexico, Chile and Costa Rica have strongly supported closer

[4]See, WSJ Going Global December, 9 1994 page R8.

[5]An example of this development is Telefonos de Mexico SA, Mexico's national telephone company and that country's largest stock in terms of market capitalization, whose price is said to be set in New York, where the company's American Depository Receipts (ADRs) are listed, and not in Mexico City.

[6]A Pan-American summit ended in December 1994 with plans to establish a free-trade zone. Thirty-four Western Hemisphere leaders agreed to establish a Free Trade Area of the Americas by 2005. The proposed free-trade zone would be the largest in the world, encompassing 850 million people with $13 trillion in purchasing power. Meanwhile, the U.S. invited Chile to begin negotiations to join NAFTA, which currently comprises the U.S., Canada and Mexico. Along with NAFTA, the major free-trade pacts in Central and Latin America are: Mercosur, which includes Brazil, Argentina, Paraguay and Uruguay; the Andean group, which includes Venezuela, Colombia, Bolivia, Ecuador and Peru; the Central American Common Market; and the Caribbean Community (Gwynne, 1994; Alonso, 1994). It is both economically and politically interesting to note that the previous summit before last December took place 27 years ago, and was held in Punta del Este, Uruguay. Latin America has changed enormously since that summit. The cold war is over and, with the single exception of Cuba, all the region's countries are democracies and believers in open markets.

economic ties with the United States through regional free trade agreements. However, countries like Brazil, Venezuela and Argentina, while recognizing the need for good economic relationships with the United States, also like to maintain a certain distance, both economically and politically, from the regional hegemonic power. At the same time, closer integration in the whole of the Americas also depends strongly on the attitude of the United States.[7]

Still, even while some stock markets are more likely to become mirror images of each other, it is unlikely that different regions will march to the same tune at the same time. Perceptive investors will spot interregional differences, and be able to capitalize on these differences.[8]

However, Solonik has found that in the mid-1970s, the U.S. stock market's correlation with Morgan Stanley's EAFE (Europe Australia Far East) Index was 0.7, just about where it is now. Moreover, Solonik's analysis of the performance of the U.S. and seven other major stock markets over the past 34 years shows that there has been only a slight increase in correlations. Although correlations increase during periods of high volatility, such as the oil shocks of the 1970s and the 1987 crash.[9] Another reason why an increase in correlation among stock markets is not likely to materialize is that countries are different in their industrial compositions and endowments. This indicates that when an investor invests in different stock markets he is buying different sets of cash flows.[10]

The dynamic linkages among the world's major markets has been studied since the late 1960s (Grubel, 1968; Granger and Morgenstern, 1970; Levy and Sarnat, 1970; Grubel and Fadner, 1971; Agmon, 1972; Bertoneche, 1979; Hilliard, 1979) and more recently (Schollhammer and Sands, 1985; Eun and Shim, 1989; Meric and Meric, 1989; Von Furstenberg and Jeon, 1989, 1991; Hamao, Masulis and Ng, 1990; Koch and Koch, 1991; Birati and Shachmurove, 1992; Chan, Gup and Pan, 1992; Malliaris and Urrutia, 1992; Roll, 1992; and Friedman and Shachmurove, 1995). However, this study is the first to investigate the dynamic linkages across national indexes of the newly emerging markets

[7]In this context, Bhagwati has claimed that if the United States pushes Free Trade Areas only southward, it will certainly invite a defensive, if not retaliatory, bloc in Asia (Bhagwati, 1993, p. 161).

[8]To borrow an example from Asia, Singapore will probably be more highly developed - even in the year 2000 - than China. Thus, the emerging growth stocks of China would not be as correlated as the big name companies who are cross listed in major stock markets over the world.

[9]Such correlations are reducing the benefits from international risk diversifications, because it is precisely when markets are volatile that investors would like to bear the benefits of risk diversifications. However, Solonik suggests that U.S. investors should have about 40 percent of their assets abroad, a figure which is higher than the 10 to 15 percent advocated by many market analysts.

[10]For example, while energy stocks represent merely 8 percent of the U.S. stock market's total capitalization, they account for none in Germany's or Switzerland's but 43 percent of the Netherlands' and 41 percent of Norway's. This indicates that when an investor invests in different stock markets he is buying a different sets of cash flows. Coffee and banana plantations are going to stay in South America; they are not going to sprout up in Germany or the United Kingdom.

of South America.

Table 1 presents an overview of emerging Latin American stock markets as of the third quarter of 1990. Determining which country takes the leading position in market size depends on how well each country's stock market and currency happens to be doing at the time, so it is not of great significance. Yet, the ordering presented is true for the period studied in this paper. The Mexican stock market is the biggest market followed by the Brazilian, Chilean and the Argentinean.

Since stock markets in different countries operate in different time zones with different closing and opening times, their returns on a given calendar day represent returns which are realized over different real time periods. Figure 1 presents the operating times of each market relative to other markets in a real time scale using New York time. As can be seen from the Figure, the Brazilian stock exchange closes at 2:30 p.m., Mexico and Argentina at 4:00 p.m. and Chile at 4:30 p.m., New York time.

The remainder of this paper is organized in the following sections. Section II summarizes the Vector Auto Regressions (VAR) model. Section III describes the data used in this study. Section IV presents the empirical results for the South American markets. Section V investigates the influences of major world stock markets on the South American markets. Section VI presents a mean-variance optimum portfolio for the four South American Market from the point of view of an international investor. Section VII summarizes.

2 THE VAR MODEL - ECONOMETRIC SPECIFICATION

The methodology employed in this paper is the Vector Auto Regressive (VAR) model. This methodology provides identification of the responses to shocks originating in different stock markets. If markets do not behave as a single regional market, the benefits from diversification may be exploited. A vector autoregression may be written as:

$$(1)\ Y(t) = C + \sum_{s=1}^{L} A(s) \cdot Y(t-s) + e(t),$$

where L denotes the number of lags, Y(t) is an n·1 vector of daily rates of return of the stock markets, C is an n·1 vector of constants, A(s) is n·n matrices of coefficients, and e(t) is n·1 column-vector of forecast errors of the best linear predictor of Y(t) using all past Y(s). By design, e(t) is uncorrelated with all the past Y(s). If this is combined with the fact that e(t) is also a linear combination of current and past Y(t), then e(t) is serially uncorrelated. The i,j-th component of A(s) measures the direct effect that a change in the return to the j-th market would have on the i-th market in time periods.[11] It is more

[11] There are a total of n2L free coefficients in this model. Since the right-hand side (RHS) of

insightful (Sims, 1980) to analyze the reaction or the response of the system of equations to typical random shocks by tracing out the following moving average representation (MAR) of the VAR:

(2) $Y(t) = \sum_{s=0}^{\infty} B(s) \cdot e(t-s)$,

where the n·n matrix of coefficients B(s) is derived from equation (1). Equation (2) expresses Y(t) as a linear combination of current and past one-step ahead forecast errors or innovations.[12]

The vector e(t) is, by construction, serially un-correlated. However, each element of the vector e(t) may be contemporaneously correlated. Thus, the error term may be transformed in different ways. Following Sims (1980), and Litterman (1984) we choose a lower triangular matrix V, utilizing the Cholesky factorization, and derive the orthogonalized innovations u from e = Vu.[13] The orthogonalized transformation of e(t) implies that equation (2) may be expressed as the following equation:

(3) $Y(t) = \sum_{s=0}^{\infty} C(s) \cdot u(t-s)$,

where C(s) = B(s)·V. The i,j-th element of C(s) represents the impulse response of the i-th market in s periods to a shock of one standard error in the j-th stock market. The orthogonalized innovation enables one to allocate the variance of each element in Y to sources in elements of u, since u is both serially and contemporaneously uncorrelated. This enables decomposition of forecast error variance into the different markets. Such a decomposition measures the overall relative importance of the markets in generating fluctuations in stock returns in all markets, including their own market. A leading market is a market that helps explain the variance of its forecast errors and can explain a high proportion of the variance of forecast errors (VFE) of other markets. A follower stock market is a market that is being explained largely by other markets and is not being able to explain the VFE of other stock markets.

3 DESCRIPTION OF THE DATA

The data base for this study consists of daily stock market indices of the four major Latin American stock markets at closing time. The countries are Mexico, Brazil, Chile and Argentina. In addition, major stock indices are used in order to investigate external shocks to the South American markets. These stock

each equation in the system of equations (1), includes the same regressors, a constant, lagged values of each variable, and the error term, estimation is relatively straight forward. However, such a system of equations contains complicated cross-equation feedback restrictions.

[12]Each element in B(s), say the i,j-th element gives the response of the i-th market in s periods after a unit random shock in the j-th market and none in other markets, conditional on the information available at time t.

[13]The transformed innovation u(t) has an identity covariance matrix, such that E(ee') = S and VV' = S.

market indices are: the US, the world excluding US (EXUS), United Kingdom (UK), Japan, Germany, France, and Canada. The indices were calculated by Morgan Stanley Capital International Perspective, Geneva (MSCIP). The data base covered the period December 31, 1987, through June 14, 1994, with a total of 1,684 observations per stock market. These stock market indices are transformed to daily rates of return, which are then used in the VAR analysis. One of the main advantage of the stock market indices compiled by the MSCIP is that these indices do not double-count those stocks which are multiple-listed on other foreign stock exchanges. Thus, any observed interdependence among stock markets cannot be attributed to the multiple listings (Eun and Shim, 1989).

4 EMPIRICAL RESULTS

4.1 Correlation Matrix of Daily Returns

Table 2 presents the correlation matrix of daily returns for the transformed data, i.e., in rates of return for the four major Latin American and the world stock markets. In this section we concentrate on the Latin American markets. Two interesting points should be noted from the table. First, all correlation coefficients are below 10 percent, the highest correlation coefficient is between Mexico and Brazil (0.088) and a close second is between Mexico and Chile (0.081). Second, the correlation coefficient of daily stock market returns between Argentina and Brazil is negative. This is interesting because international diversification of stock markets portfolio will be able to exploit such a negative correlation, i.e., the aggregate variance may be reduced in expectations. In addition, based on Table 2, it seems that Mexico has higher correlation with Brazil and Chile. The Argentine stock market is more independent of the other markets.

4.2 Unit Roots Tests

Appendix 1 presents a series of unit roots tests that are calculated. When the data is transformed to rates of return, i.e., the natural log of the stock index in market j at time t, minus the natural log of the stock index in market j at time (t-1) (and multiplied by 100), the hypotheses for unit roots are rejected for each and every stock market j.

4.3 Choosing the Lag Length of the VAR Model

Appendix 2 details different test for choosing the lag length of the VAR system. Based on the Likelihood Ratio Test (Sims, 1980) it seems that a lag length of 15 lags captures most of the dynamic in the data.

4.4 Contemporaneous Residual Correlation Coefficients

As with the correlation of daily returns it is apparent that the contemporaneous residual correlation coefficients are not high. The highest correlation coefficient, between Mexico and Chile, is less than 10 percent. The residuals, or innovations, represent abnormal stock market returns that were not predicted on the basis of all the information reflected in past returns. The contemporaneous correlations of daily residual returns measure the degree to which new information produces an abnormal return in one market is correlated by the other market in the same calendar day. The more integrated any two of the economies are, the more strongly movements in one stock market would be correlated with those in another market. It is interesting to note (see Table 3) that the Chilean stock market is relatively highly correlated with the relatively geographically far away market of Mexico. The two geographically close market of Chile and Argentina who share a long, but not always easy to cross, border has a contemporaneous correlation of only 0.06. These results are in contrast with both Eun and Shim (1989) and Friedman and Shachmurove (1995) who found that geographical proximity matters.

4.5 Granger - Causality Tests

Having decided on the lag length of fifteen trading days, Table 4 presents the block-F tests, or Granger Causality tests. The tests indicate whether a variable, say the return in the Mexican stock exchange helps to forecast the stock market return of the Argentinean stock exchange one-step ahead. It is worth noting that the Mexican return can still affect, for example, the Argentinean return through other equations in the system.

The rows in Table 4 are the affecting or influencing markets whereas the columns are the affected markets. In other words, each column represents an equation where the dependent variable is written at the column's heading and the rows are the regressors or the independent variables. The VAR system includes 15 lagged daily returns for each stock markets, a constant and a trend. The Argentinean, the Mexican and the Chilean stock markets are affected only by their own lags. The Brazilian stock market is affected both by its own lagged values as well as by the Argentinean market. Based on the block-F tests it seems that the most influential market in the South American major markets is the Argentinean market which Granger-cause the Brazilian stock market, and the only affected market is the Brazilian stock exchange.

4.6 Decomposition of Forecast Variance

Tables 5A-5B present the results of the decomposition of variances. Table 5A shows a system which is shocked according to the closing time of the exchanges; first, the Brazilian market and then the two markets of Mexico and Argentina

and finally the Chilean market (see Figure 1). About 4 percent of the variance of Brazil is explained by its neighbors, especially by Argentina. Mexico seems more independent; only about 2 percent of its variance of forecasted error is explained by the other South American markets. The same is true for Argentina. The market of Chile is influenced by all other three markets. The markets of Brazil and Chile are more affected by Argentina and Mexico. These patterns seem to carry over in the other ordering of the stock markets (Tables 5B and other tables which are available from the author).

4.7 The Moving Average Representations For the Four South American Stock Markets

Further insights of the dynamic correlations can be obtained by plotting the impulse responses which result from different simulations. A shock of one standard deviations is introduced to one of the markets and its dynamic effects in the following 24 trading days are plotted. In this way it is possible to study the dynamic responses of each of the markets to innovations in a particular market using the simulated responses of the estimated VAR model. Figures 2-5 plot the simulated responses to each market by a shock in each of the four stock markets. The vertical axis represents the deviation from the benchmark case, while the horizontal axis represents the horizon days from the day of the shock up to 24 trading days. Figure 2 plots the responses to the Brazilian market. Figure 3 plots the responses to the Mexican, Figure 4 to the Argentinean and Figure 5 to the Chilean markets. Figures 6-9 present simulated responses of each market to a one standard deviation shock in each market, including its own market. By and large, there are dynamic linkages among the markets, although the responses are small. The main effects take place in the first 2-3 days. Brazil is affected by Argentina and by Chile. Mexico affects Argentina, and Mexico is affected by Brazil, Argentina affects Chile even after 9 trading days.

Friedman and Shachmurove (1995) advances the idea of an event in one market that is directly transmitted to another market, rather than the heat-waves and meteor showers hypotheses, first introduced in the foreign exchange markets (Engle, Ito, and Lin, 1990; and Ito, Engle and Lin, 1992). The heat wave hypothesis assumes that volatility has only country-specific autocorrelations. The meteor shower hypothesis allows volatility spill-overs across markets, from one to the other in some order of the stock exchanges. The following simulations can be visualized as a hand grenade that explodes in one market and ricochets to other markets, ignoring its effects, or the ordering on other markets. Figures 10-13 present such simulations. The figures are presented in columns and then the rows from left to right. Figure 10 presents the effects of the Brazilian market on itself, on Mexico, on Argentina and on Chile. The Brazilian market, shocked positively by one standard deviation is affected for more than 5 trading days after the shock. The effects on the Mexican and the Chilean markets die after one trading day. The effect on the Argentinean market is felt mostly on the

second day (about 25 percent of the size of the standard deviation) followed by negative adjustments. Figure 11 presents the effect of Mexico on Mexico and the other South American stock markets. The Mexican shock dies out in two days in its own market. The Mexican market is affecting the markets of Argentina and Brazil with a size of about 20 percent and the market of Chile by about 10 percent of the standard error. The effect of the Argentinean market (Figure 12) is interesting as well. There are almost erratic, although dampening, jumps of over and under shooting from the long run position. We see a strong effect on Brazil, particularly six days after the event and almost no effects on the Mexican and Chilean markets. The Chilean shock dies out after 3 days in its own market. The effect on the Argentinean market is interesting with both positive and negative adjustments. Figure 13 plots the effects of the Chilean market. Of a particular interest is the Chilean effect on the Argentinean market (above 0.3 in the first day after the shock to the Chilean market).

5 EXTERNAL SHOCKS TO SOUTH AMERICAN MARKETS

In this section we investigate the interrelationships among the major South American markets that we have been studying thus far and major world markets. These indices are: Mexico, Brazil, Chile, Argentina, US, world excluding US, UK, Japan, Germany, France, and Canada.

5.1 Correlation Matrix of Daily Returns

Table 2 presents the correlation matrix of daily returns for major South American and major world markets in the period studied in this paper. Argentinean stock market daily returns are negatively correlated with that of France (-0.04), and negatively or almost zero correlated with that of Germany, Japan, UK and the world excluding US (EXUS). It is positively correlated with the US (0.02). Mexico is positively correlated with the Canadian (0.03), the UK (0.05), and EXUS (0.04). Mexico is also negatively correlated with the Japanese and the German markets. Brazil is positively correlated with the UK and the US (about 4 percent each) and with EXUS, Japan and France (about 2 percent each) and negatively correlated with Germany (-0.02). Chile is correlated mainly with Germany and Japan.

5.2 Granger - Causality Tests

The F-tests for the affects of major non South American markets and the South American markets are presented next in Tables 6A - 6B. Each VAR system consists of the four South American markets and an additional non-South American

market. In all the 5- equation VARs, as above in the only four South American VARs, the Brazilian market is affected by Argentina in addition to its own lags. The US, Canadian, French, German, UK, and the world excluding US stock indices are influenced by the Chilean market. The French stock market is affected by the Chilean market as well. The Japanese stock market is affected to a lesser extent, relative to the French, by the Chilean market, and the Chilean market is affected by the Japanese stock market, in addition to its past lags. Finally, Table 6B presents the VAR system with all the available eleven daily stock returns. All countries are affected by their own lags. In addition, Argentina is affected by France, Mexico by the world excluding the US index, Brazil is affected by Argentina, and Chile is affected by Japan, the UK, and the EXUS. The conclusion is that dynamic interrelationships exist among the South American emerging markets and the other major developing countries stock indices.

5.3 Decomposition of Forecast Variance For SA and World Stock Indices

The decompositions of variances are presented for the four South American markets and the external stock index of the U.S. appears in Tables 7. It is interesting to note that the Chilean stock index is explaining about 3.5 percent of the forecast error variance for the U.S. Furthermore, about 7.2 percent of the forecast variance of the U.S. stock market is explained by the four SA markets. Moreover, the U.S. market has less affect on the SA markets. Similar results, to varying degrees are true for all the external markets investigated and are available from the author. The conclusion is that although we have seen opportunities for diversifications, dynamic linages exist and should not be played down. Similar conclusions can be reached using the other external markets.

5.4 The Moving Average Representations with External Markets

Because of space limitations, the figures for a VAR systems which includes the four South American and one external market are presented only for the US market. The order is according to closing time of the exchanges (Figure 1). Figures 14-18 present the simulation results for the US. Figure 14 presents the simulation of the US effects on itself and on the other four South American markets. This figure can be compared to the results reported in Eun and Shim (1989). Eun and Shim (1989) report the effects of the US in a VAR model on eight developed countries for the period January, 1980 to December, 1985. The countries they studied include, in addition to the US, the stock markets of Australia, Canada, France, Germany, Hong Kong, Japan, Switzerland and the UK. They found that innovations in the US stock market are rapidly transmitted to all the other markets in responses of sizes of between 0.2 to point 0.4 (except,

the Canadian with a high response of 0.6). In our sample, and for the South American emerging stock exchanges, the US market affects mainly Argentina and Brazil. The response of Argentina is about 0.18 and the response of Brazil is about 0.15 in the first two days after the shock. The responses of Mexico and Chile are almost zero. Chile affects the US on the 9-th business day. The simulations of the impulse responses for other external markets and the South American markets are available from the author.

6 A Mean-Variance Optimum Portfolio

In this section we present the optimum portfolio (Grauer and Hakansson, 1987). Figure 19 and Table 8 present the optimum portfolio of the four stock markets where the US T-bill represents the return on the safe asset. The optimal weights are 7.85 for Argentina, 40.1 for Mexico, about 8 percent for Brazil and 44 percent for Chile. The expected annual return on such a portfolio is about 60 percent with a standard deviation of 21 percent.

7 Conclusions

This paper formulates and estimates a series of VAR econometric models. The models are used to study the dynamic interrelationships among the four major stock markets of South America and among the SA markets and the major world stock markets. Through a series of simulations the dynamic responses are studied and analyzed. Although most of the impulse responses die out very quickly, it is still possible to trace the dynamic linkages among markets. These linkages are non linear functions involving fifteen lags and tens (in the four-variable VARs) or hundreds of coefficients (in the 11-variable VARS). Within the SA markets, no market is found to be completely independent. Moreover, different simulations yield different results indicating that different shocks which are transmitted differently from one market to the other are going to affect the stock markets differently. The conclusion is thus that although market are efficient and cleared out in few trading days, there are dynamic linkages that can be explored and exploited to the benefits of the international investor. Stock markets do not march to the beat of the same drummer. Thus, diversification make sense even when global markets become more accessible.

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Appendix 1

This appendix details the unit roots tests performed in this paper. Four tests are displayed. The first test, DFT, presented in column one of Table A1, is the Dickey-Fuller test. The methodology allows for testing a unit root in AR(1 + LAGS) representation (Fuller, 1976; Dickey and Fuller, 1979). With a positive value for LAGS the test is the Augmented Dikey-Fuller test, ADF. The results of the Augmented Dickey-Fuller test, ADF, is presented in column 2 of Table A1. The third test, PPT, is the Phillips-Perron unit root test (Phillips, 1987; Phillips and Perron, 1988) presented in column number 3 of the Table. The fourth test, BURT implements the Bayesian Unit Root Test suggested by Sims (Sims, 1988) and corrected by Doan (Doan, 1994). A small value of Marginal Alpha indicates that the data evidence is strongly against the unit-root hypothesis. The BURT is presented in column number 4 of Table A1. The results presented in Table A1 are first for the raw data in levels, Table A1-1, then in natural logs, Table A1-2, and finally in rate of return, Table A1-3. The existence of unit roots cannot be rejected for all markets when the indices are measured in their levels or in their natural logarithms. However, it is clear that when the data is transformed to rates of return, i.e., the natural log of the stock index in market j at time t, minus the natural log of the stock index in market j at time (t-1) (and multiplied by 100), - the hypotheses for unit roots are rejected for each and every stock market j.

TABLE A1-1: UNIT ROOTS TESTS ON THE LEVELS OF THE STOCK MARKETS INDICES 1987- 1994

Country	DFT	ADF	PPT	BURT
ARGENTINA	-1.938	-2.136	-1.932	0.991
MEXIO	-0.282	-0.494	-0.442	0.997
BRAZIL	-3.794	-5.925	-5.480	0.981
CHILE	1.387	1.146	1.165	0.992

*

DFT is the Dickey-Fuller Test with 0 Lag.
ADF is the Augmented Dickey- Fuller Test with 1 lag.
PPT is the Phillips-Perron Test with 4 Lags.
BURT is the Bayesian Unit Root Test suggested by Sims.
*

TABLE A1-2: UNIT ROOTS TESTS ON THE LOG OF THE LEVELS OF THE STOCK MARKETS INDICES 1987 - 1994

COUNTRY	DFT	ADF	PPT	BURT
ARGENTINA	-4.013	-3.710	-3.362	0.973
MEXICO	-1.448	-1.679	-1.595	0.988
BRAZIL	-4.726	-6.784	-7.005	0.970
CHILE	-0.287	-0.458	-0.404	0.997

TABLE A1-3: UNIT ROOTS TESTS ON THE DAILY RETURNS OF THE STOCK MARKETS INDICES 1987 - 1994

COUNTRY	DFT	ADF	PPT	BURT
ARGENTINA	-1773.085	-2523.299	-1647.713	0.000
MEXICO	-1241.076	-1402.610	-1213.767	0.000
BRAZIL	-1377.423	-1188.892	-1463.796	0.000
CHILE	139.133	-1367.877	-1317.661	0.000

Appendix 2

This appendix presents the tests for choosing the lag length of the VAR system. In general three tests are proposed for choosing the lag length. The first is the Akaike Information Criterion, AIC, (Akaike, 1973), the second is the Schwarz Criterion (Schwarz, 1978) and the third is the Likelihood ratio test as modified by Sims (Sims, 1980). The first two tests are really single-equation tests which use a function of the residual sum of squares together with a penalty for large numbers of parameters. The selection of the lag length is based on minimizing the criterion function over different alternatives for the lag length. Since the Schwarz Criterion places a heavier penalty on additional parameters, the Criterion never choose a lag length which is larger than the one chosen by the Akaike Criterion. Specifically, the Akaike Criterion minimizes the expression:

T·log(RSS) + 2·K,

where T is the number of observations, RSS is the sum of squared residuals, and K is the number of regressors. The Schwarz Criterion minimizes the expression:

T·log(RSS) + K·(log T).

I have tested for lag length ranging from one to 30 lags. For Argentina, the lag length is three and two for Akaike and Schwarz, respectively. For Mexico, the lag length is two and one lag. For Brazil, five lags for the first criterion and only one lag for the second criteria. For Chile, the lag length is one lag based on the two criteria.

However, in a VAR system, the hypotheses to be tested include more than one equation. The test recommended in this case is based on the Likelihood Ratio Test as follows:

(T - C) · (log $\mid \sum r - \sum u \mid$),

where T is the number of observations, C, is the correction suggested by Sims to improve small sample properties (Sims, 1980, page 17), r and u are the restricted and the unrestricted covariance matrices. The correction, C is equal to the number of variables in each unrestricted equation in the system . The above expression is asymptotically distributed as a 2 with degrees of freedom equal to the number of restrictions. I have experimented with length lags up to 30 lags. It seems that a lag length of 15 lags captures most of the dynamic in the data (detailed results are available upon a request). Similar results were found in Eun and Shim (1989) for daily stock markets of nine major world markets and Friedman and Shachmurove (1995) study of the European stock markets. The lesson that should be inferred from the above exercises is that researchers need to take into account that the estimation is of a system of equations rather than single-equation. Applying such a measure will lead to inclusion of 15 lags in the VAR system.

The following abbreviations are used where needed in tables 1-8: Argentina (ARG), Mexico (MEX), Brazil (BRAZ), Chile (CHIL), Canada (CAN), France (FRN), Germany (GER), Japan (Jap), United Kingdom (UK), World excluding the United States (EXUS), and United States (US).

TABLE 1: OVERVIEW OF EMERGING LATIN AMERICAN STOCK MARKETS THIRD QUARTER 1990

Country	**Market Capitalization**	**Number of Listed Companies**	**Ave. Daily Values Traded for Quarter**	**P / E**
ARG	3.438	174	3.16	-4.35
BRAZ	24,907	584	17.56	7.18
CHILE	11,216	216	2.82	6.17
MEX	27,998	205	52.65	10.27

P/E = Price/ Earnings Ratio

Market Capitalization and Average Daily Values traded for quarter are in USD Millions.

TABLE 2a: CORRELATION MATRIX OF DAILY RETURNS FOR MAJOR STOCK MARKET INDICES: 1987- 1994.

	ARG	**MEX**	**BRAZ**	**CHIL**	**CAN**	**FRN**
ARG	1.00	0.03	-0.03	0.05	0.02	-0.04
MEX	0.03	1.00	0.09	0.08	0.03	0.001
BRAZ	-0.03	0.09	1.00	0.07	0.03	0.02
CHIL	0.05	0.08	0.07	1.00	-0.01	-0.03
CAN	0.02	0.03	0.03	-0.01	1.00	0.04
FRN	-0.04	0.001	0.02	-0.03	0.04	1.00
GER	-0.00	-0.01	-0.02	0.03	0.02	0.63
JAP	-0.01	-0.02	0.03	0.02	-0.07	0.29
UK	-0.01	0.05	0.04	0.004	0.04	0.55
EXUS	-0.01	0.03	0.02	-0.01	0.41	0.17
US	0.02	-0.01	0.04	0.003	0.65	-0.04

TABLE 2b: CORRELATION MATRIX OF DAILY RETURNS FOR MAJOR STOCK MARKET INDICES: 1987- 1994 cont.

	GER	JAP	UK	EXUS	US
ARG	-0.001	-0.01	-0.01	-0.01	0.02
MEX	-0.01	-0.02	0.05	0.03	-0.01
BRAZ	-0.020	0.03	0.04	0.02	0.04
CHIL	0.03	0.02	0.004	-0.01	0.003
CAN	0.02	-0.07	0.04	0.41	0.65
FRN	0.63	0.29	0.55	0.17	-0.05
GER	1.00	0.34	0.46	0.09	-0.05
JAP	0.34	1.00	0.36	0.03	-0.05
UK	0.46	0.36	1.00	0.14	-0.06
EXUS	0.09	0.03	0.14	1.00	0.25
US	-0.05	-0.05	-0.06	0.25	1.00

TABLE 3: COVARIANCE\CORRELATION MATRICES OF RESIDUALS DAILY RETURNS FOR A VAR WITH 15 LAGS

	R-ARG	R-MEX	R-BRAZ	R-CHIL
R-ARG	27.133	0.031	-0.021	0.062
R-MEX	0.247	2.298	0.073	0.099
R-BRAZ	-0.353	0.359	10.278	0.058
R-CHIL	0.419	0.194	0.244	1.677

TABLE 4: F-TESTS FOR GRANGER CAUSALITY VAR WITH 15 LAGS OF DAILY RETURNS FOR FOUR MAJOR LATIN AMERICAN STOCK MARKETS

AFFECTED MARKETS				
COUNTRIES AFFECTING	ARGENTINA	MEXICO	BRAZIL	CHILE
F-Statistic				
ARGENTINA	6.753**	0.605	2.715**	0.737
MEXICO	1.042	10.035**	1.304	0.759
BRAZIL	0.819	0.713	6.083**	0.702
CHILE	1.031	0.353	1.161	4.721**

** Statistically significant at one percent.

TABLE 5a: DECOMPOSITION OF VARIANCES FOR (DCOVF) MAJOR LATIN AMERICAN STOCK MARKETS ACCORDING TO MARKET CLOSING TIME. THE ORDER IS BRAZIL MEXICO ARGENTINA CHILE - 15 LAGS

DCOVF	STEP	Standard ERROR	BRAZ	MEX	ARG	CHIL
BRAZ	5	3.289	99.147	0.153	0.617	0.080
	10	3.335	97.193	0.412	1.966	0.427
	15	3.359	96.053	0.783	2.149	1.013
	20	3.362	95.996	0.821	2.163	1.017
	24	3.363	95.983	0.829	2.167	1.019
MEX	5	1.569	0.570	99.134	0.153	0.141
	10	1.585	0.816	98.718	0.289	0.175
	15	1.593	1.039	98.211	0.514	0.235
	20	1.595	1.052	98.145	0.533	0.268
	24	1.595	1.053	98.135	0.536	0.274
ARG	5	5.336	0.409	0.501	98.969	0.120
	10	5.399	0.663	0.759	98.189	0.386
	15	5.421	0.750	0.930	97.807	0.510
	20	5.439	0.752	0.958	97.432	0.856
	24	5.440	0.758	0.967	97.417	0.856
CHIL	5	1.323	0.468	1.074	0.585	97.871
	10	1.329	0.519	1.495	0.921	97.063
	15	1.337	1.036	1.617	1.045	96.300
	20	1.339	1.112	1.758	1.068	96.061
	24	1.339	1.114	1.765	1.081	96.039

DCOV denotes Decomposition of Variance for

TABLE 5b: DECOMPOSITION OF VARIANCES FOR MAJOR LATIN AMERICAN STOCK MARKETS ACCORDING TO MARKET CAPITALIZATION MEXICO BRAZIL CHILE ARGENTINA - 15 LAGS.

DCOVF	STEP	Standard Error	MEX	BRAZ	CHIL	ARG
MEX	5	1.569	99.648	0.056	0.129	0.166
	10	1.585	99.292	0.242	0.163	0.302
	15	1.593	98.791	0.458	0.235	0.513
	20	1.595	98.822	0.475	0.269	0.532
	24	1.595	98.712	0.476	0.274	0.536
BRAZ	5	9.289	0.731	98.570	0.084	0.613
	10	3.335	0.992	96.613	0.470	1.923
	15	3.359	1.320	95.516	1.035	2.127
	20	3.362	1.353	95.465	1.039	2.141
	24	3.363	1.359	99.452	1.041	2.146
CHIL	5	1.323	1.169	0.373	98.310	0.146
	10	1.329	1.581	0.432	97.496	0.488
	15	1.337	1.729	0.924	96.730	0.615
	20	1.339	1.884	0.985	96.493	0.636
	24	1.339	1.892	0.986	96.471	0.648
ARG	5	5.336	0.524	0.385	0.543	98.546
	10	5.399	0.774	0.648	0.862	97.713
	15	5.421	0.940	0.740	0.975	97.342
	20	5.439	0.968	0.742	1.296	96.992
	24	5.440	0.977	0.748	1.297	96.977

DCOVF denotes Decomposition of Variance for

TABLE 6a-1: F-TESTS FOR GRANGER CAUSALITY VAR WITH 15 LAGS OF DAILY RETURNS FOR FOUR MAJOR SOUTH AMERICAN AND AN EXTERNAL MAJOR WORLD STOCK MARKETS.

	AFFECTED MARKET				
Countries Affecting	**External Market**	**ARG**	**MEX**	**BRAZ**	**CHIL**
US	2.2333**	0.5897	0.6798	0.7179	0.7050
ARG	0.625	6.7336**	0.6231	2.6478**	0.7335
MEXICO	0.9171	1.0359	10.0575**	1.3136	0.7782
BRAZIL	1.1473	0.8213	0.7384	5.7797**	0.7253
CHILE	3.9559**	1.1502	0.3666	1.1079	4.6129
CANADA	5.2026**	0.8895	0.9509	0.7651	0.6799
ARG	0.7803	6.7582**	0.6037	2.6978**	0.7533
MEXICO	0.7000	1.0458	9.8176**	1.2712	0.7663
BRAZIL	0.8558	0.8421	0.6496	5.9696**	0.7243
CHILE	7.0376**	1.1637	0.3885	1.1909	4.7737**
FRANCE	1.8237*	1.4432	1.3452	0.9291	0.7721
ARG	0.9382	6.3951**	0.6243	2.6687**	0.7028
MEXICO	0.6113	1.0599	10.0265**	1.2358	0.7918
BRAZIL	1.0900	0.9067	0.7176	5.9567**	0.7787
CHILE	1.8725*	1.1451	0.3750	1.1083	4.6938**
GERMANY	1.0380	1.0503	1.4809	1.2661	0.7353
ARG	0.8763	6.6256**	0.6713	2.6071**	0.7688
MEXICO	0.6568	1.0885	9.8085**	1.1989	0.7576
BRAZIL	1.4000	0.8252	0.6947	6.1441**	0.7606
CHILE	1.7521*	1.1688	0.3653	1.0592	4.7289**

** statistically significant at 1 percent.

* statistically significant at 3 percent.

&- statistically significant at 10 percent.

TABLE 6a-2: F-TESTS FOR GRANGER CAUSALITY VAR WITH 15 LAGS OF DAILY RETURNS FOR FOUR MAJOR SOUTH AMERICAN AND AN EXTERNAL MAJOR WORLD STOCK MARKETS, Cont.

	AFFECTED MARKET				
Countries Affecting	**External Market**	**ARG**	**MEX**	**BRAZ**	**CHIL**
JAPAN	2.6511**	0.6582	1.1549	1.0846	2.6809**
ARG	0.6433	6.5490**	0.5885	2.8700**	0.7849
MEXICO	0.7383	1.0418	9.8905**	1.3005	0.9046
BRAZIL	0.7497	0.7614	0.7019	6.1428**	0.7248
CHILE	1.5721&	0.9912	0.4364	1.2368	5.0996**
UK	1.7748*	0.6580	0.9352	1.1484	0.6016
ARG	0.7416	6.6730**	0.6134	2.7606**	0.7774
MEXICO	1.2001	1.0404	10.1271**	1.2792	0.7068
BRAZIL	1.2632	0.8389	0.7364	6.0206**	0.7865
CHILE	3.1835**	1.0478	0.3950	1.1966	4.6659**
EXUS	2.7848**	0.7929	1.7633*	1.2403	0.7271
ARG	0.9208	6.7586**	0.6088	2.8361**	0.7771
MEXICO	0.7530	1.0695	10.0685**	1.2603	0.7458
BRAZIL	1.2467	0.8108	0.7429	6.0927**	0.7883
CHILE	4.0657	1.0788	0.5300	1.1253	4.6548**

** statistically significant at 1 percent.
* statistically significant at 3 percent.
&- statistically significant at 10 percent.

TABLE 6b-1: F-TESTS FOR GRANGER CAUSALITY VAR WITH 15 LAGS OF DAILY RETURNS FOR FOUR MAJOR SOUTH AMERICAN AND THE WORLD STOCK MARKETS

	AFFECTED MARKETS					
COUNTRIES AFFECTING	F-Statistic					
	ARG	**MEX**	**BRAZ**	**CHIL**	**CAN**	**FRN**
ARG	5.96**	0.75	2.94**	0.81	0.73	1.43
MEX	1.07	9.19**	1.23	1.00	0.64	0.70
BRAZ	0.90	0.68	5.84**	0.94	0.97	0.59
CHIL	1.34	0.62	1.35	5.20**	3.42**	1.24
CAN	0.66	0.70	1.31	0.75	3.98**	1.25
FRN	1.85*	1.21	1.12	1.14	2.31**	0.79
GER	1.38	1.27	1.02	0.96	0.91	1.56&
JAP	1.06	1.03	0.58	5.30**	6.10**	1.16
UK	0.61	0.91	1.00	1.50*	1.75	2.03**
EXUS	1.13	1.84*	0.63	3.03**	5.53**	35.01**
US	0.39	0.54	1.43	1.10	7.08**	5.65**

** Statistically significant at one percent.
* Statistically significant at 3 percent
&- Statistically significant at 10 percent

TABLE 6b-2: F-TESTS FOR GRANGER CAUSALITY VAR WITH 15 LAGS OF DAILY RETURNS FOR FOUR MAJOR SOUTH AMERICAN AND THE WORLD STOCK MARKETS, Cont.

	AFFECTED MARKETS				
COUNTRIES					
AFFECTING	F-Statistic				
	GER	**JAP**	**UK**	**EXUS**	**US**
ARG	0.84	0.62	0.75	1.09	0.38
MEX	1.22	0.62	1.99**	0.84	0.88
BRAZ	1.37	0.82	0.80	1.23	1.31
CHIL	1.40	0.55	1.22	2.08**	2.03**
CAN	0.98	2.82**	2.56**	0.97	2.87**
FRN	1.47&	0.90	1.82*	1.07	2.01**
GER	1.16	1.50	1.08	1.32	1.13
JAP	1.15	6.13**	1.36	3.30**	11.74**
UK	1.36	2.47**	2.14**	0.58	1.86*
EXUS	34.65**	179.97**	45.55**	2.44**	10.18**
US	4.10**	1.39	3.04**	10.40**	3.65**

** Statistically significant at one percent.
* Statistically significant at 3 percent
&- Statistically significant at 10 percent

TABLE 7: DECOMPOSITION OF VARIANCE FOR (DCOVF): SOUTH AMERICA AND THE US

DCOVF	STEP	Error Value	US	ARG	MEX	BRA	CHIL
US	10	1.101	95.773	0.250	0.532	0.626	2.816
	20	1.114	93.924	0.692	0.813	1.052	3.517
	24	1.114	93.881	0.695	0.829	1.060	3.533
ARG	10	5.394	0.517	97.864	0.654	0.579	0.384
	20	5.438	0.656	96.982	0.861	0.672	0.826
	24	5.439	0.658	96.950	0.877	0.681	0.832
MEX	10	1.583	0.325	0.415	98.821	0.236	0.201
	20	1.595	0.517	0.674	98.055	0.463	0.288
	24	1.595	0.523	0.677	98.034	0.465	0.298
BRA	10	3.329	0.733	1.883	1.004	95.945	0.433
	20	3.362	1.074	2.095	1.346	94.452	1.031
	24	3.362	1.074	2.099	1.352	94.440	1.032
CHIL	10	1.327	0.282	0.942	1.533	0.455	96.786
	20	1.338	0.590	1.083	1.841	1.035	95.447
	24	1.339	0.594	1.096	1.848	1.038	95.422

DCOVF denotes Decomposition of Variance for
Error Value denotes Standard Error

TABLE 8: A MEAN-VARIANCE OPTIMUM PORTFOLIO

COUNTRY	EXPECTED ANNUAL RETURN	S.D.	WEIGHT (PERCENT)
ARGENTINA	1.101	1.009	7.85
MEXICO	0.627	0.312	40.17
BRAZIL	0.562	0.636	7.92
CHILE	0.492	0.254	44.06
PORTFOLIO	0.599	0.218	100.00