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A cointegration approach to the effects of external shocks on the stock exchange. The experience of Chile and Mexico.

I. INTRODUCTION

It is well established, both theoretically and empirically, that domestic and external factors affect the behavior of the stock exchange. However, no study has yet determined if such an influence is a well defined, long-run relationship or if it is merely speculative. This paper is focused, precisely, to analyze the impact of external factors on two stock exchanges: the Chilean and the Mexican bolsas. By implementing Engle and Granger's (1987) cointegration approach, we test if there exists a long-run relationship between the bolsas and two major external variables: the Dow-Jones stock index, the price of copper -in the Chilean case- and the price of oil -in the Mexican case. The results obtained suggest cointegration in the Mexican stock market, but not in the Chilean bolsa. This result implies that profitable rules can be developed in the Mexican stock exchange to earn higher than normal profits, rules that can not be implemented in the less efficient Chilean market.

Once the long-run relationship is tested, we examine the incidence of the permanent and transitory components of the external variables on the Mexican stock index. Quite interestingly, it is found that transitory movements in the Dow Jones index are of considerable importance in explaining the behavior of the Mexican bolsa.

The paper is organized as follows. The next section briefly reviews previous work on the relationship between international capital markets. Then it is included a simple dynamic model to explain the short and long-run effects of external shocks on domestic stock exchanges. The fourth section incorporates the cointegration analysis and the permanent-transitory decomposition analysis. Finally, the major conclusions are presented.

II. INTERNATIONAL STOCK EXCHANGE RELATIONSHIPS

The linkage of international stock markets is commonly explained either with the international capital asset pricing model (ICAPM), with the information lag theory (time zones) or with the approach of systematic elements affecting the markets analyzed.

The studies based on the ICAPM -- Cho, Eun and Senbet (1986), Grubel (1968), Levy and Sarnat (1969) and Solnik (1983) among others-- show that international diversification, in addition to domestic diversification, greatly reduces systematic portfolio risk. In a similar fashion to traditional asset diversification models, these studies show that the lower is the correlation between domestic and foreign assets, the more attractive is for investors to diversify internationally. Following this approach, Levy and Sarnat estimated that an American investor optimizes his portfolio by assigning 4.3% of his investment to the Mexican market, percentage above those obtained for Austria, Denmark and Britain.

Eun and Resnick (1984), Jaffe and Westerfield (1985) and Becker, Finnerty and Gupta (1990) use the time zones approach to explain the relationship between international stock exchanges. For example, there is an eight and one-half hour difference between the closing of the Tokio stock exchange and the opening of the New York stock exchange. Then, there is no overlap between the two markets, and the movement in one market may be a good short-run predictor of the behavior of the other.

These studies, however, present quite different econometric results: on the one hand, Jaffe and Westerfield reject the time zones hypothesis, while Becker, Finnerty and Gupta, on the other, estimate that the S&P index performance greatly influences (up to 35%) the movements of the Nikkei index.

Finally, the linkage of stock exchanges has been explained by the presence of common movements between markets. Given that domestic economic conditions are reflected in the stock exchange, there might exist systematic variations in stock prices if there are similar economic patterns in different countries. Then, It follows that nations with strong commercial or capital links may have a similar behavior in their stock exchanges. Within this theory,
Ripley (1973) shows the existence of comovements in the U.S. and Canada stock markets. Agmon (1974) suggests that the U.S. stock market explains 71% of the German, 46% of the Japanese and 42% of the British stock market movements. The relationship between the U.S. and British markets is also proved by Shiller (1989).  

In this paper we intend to explain the influence of external factors on the Mexican and Chilean stock markets. Several reasons explain the selection of these two countries. First, they have undoubtedly one of the less restrictive trade regimes in international standards. Second, they have very few restrictions to capital flows, and have implemented changes in their investment legislation to favor foreign financial investment. Third, both countries trade in the American market through the Fondo México and the Fondo Chile. These three explanations suggest that there may be a close link of the Chilean and Mexican stock exchange indexes with the American market. Movements in the Dow Jones index, however, are not the only external shocks that may induce a reaction of the domestic bolsa. Given that total exports of these countries depend heavily on the performance of one sector -oil in Mexico and copper in Chile-, price changes of these goods may considerably affect their stock exchange index.  

Naturally, there are several other variables not considered in this paper that may affect the behavior of the stock exchange, such as the inflation rate, the liquidity of the economy and the trade deficit. In addition, depending on deepening of the market, the domestic stock index may be critically influenced by the behavior of few stocks. This is, precisely, the case of the Mexican index.  

**III. THE MODEL**

To analyze the relationship of the stock exchange index and external variables, this section develops an IS-LM type model, where the short run adjustment lies on the stock value rather than on the interest rate. The absorption or expenditure of the economy (A) is considered to depend on income (y) and the value of stock held (q). Income affects consumption and, then, absorption. The

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1 The statistical works by Agmon (1974) and Becker, Finnerty and Gupta (1990) have extremely serious spurious correlation problems. It is precisely this major shortcoming what is avoided in the paper by implementing cointegration.

2 Both in Mexico and Chile the average tariff rate is very close to 10%.

3 In 1990, oil exports represented 37% of total Mexican exports, whereas copper represented 45% of Chilean exports.


5 Approximately 70% of the index is conformed by only seven stocks, with the shares of the telephone company (TELMEX) having the greatest percentage (35%).
stock value influences consumption, through the wealth effect, and investment, through Tobin's "q". Absorption is then specified as

\[(1) \quad A = \alpha q + \beta y\]

being \( \alpha \) and \( \beta \) the marginal propensities. It is also considered that output has a slow adjustment process with respect to excess expenditure \((A-y)\)

\[(2) \quad y = \tau(A-y) = \tau(\alpha q - (1-\beta)y)\]

where \( y \) is the change of output through time and \( \tau \) is the speed of adjustment. Equation (2) then represents the dynamics of adjustment in the goods market.

In the stock market, on the other hand, it is assumed the fulfilment of the next arbitrage condition

\[E(q_{t+1}/\Omega_t) - q_t + D = 1 + \theta\]

where the left hand side of the equation is the expected return on the risky asset and the right hand side embodies the rate of return of the risk free asset \((r)\) adjusted by a risk factor \((\theta)\). The return on the risky asset is conformed by the expected capital gain \(((E(q_{t+1}/\Omega_t) - q_t) / q_t)\) plus real dividends \((D/q)\). Assuming perfect foresight, this expression reduces to

\[(3) \quad q = q(r + \theta) - D\]

In order to introduce the external variables into the framework, we consider that dividends are a direct function of domestic output, the behavior of the foreign economy -represented by the New York stock exchange index \((dow)\)- and the price of the main export good \((px)\):

\[(4) \quad D = \lambda_0 + \lambda_1 y + \lambda_2 px + \lambda_3 dow + \epsilon\]

where \( \epsilon \) is a random error. Incorporating (4) into (3) yields

\[(5) \quad q = q(r + \theta) - (\lambda_0 + \lambda_1 y + \lambda_2 px + \lambda_3 dow)\]

Equations (2) and (5) represent a simple system of differential equations. From (2) it follows that the steady state of output level is:

\[(6) \quad \dot{y} = 0 \Rightarrow q = (1-\beta)/\alpha\]
Similarly, the steady state of the stock value follows from (5):

\[(7) \quad q = 0 \Rightarrow q = (\lambda_0 + \lambda_1 y + \lambda_2 px + \lambda_3 dow + \varepsilon) / (r + \theta)\]

Equations (6) and (7) represent then the equilibrium conditions in the goods and stock market respectively. The slopes for each steady state locus are determined by

\[\Delta q / \Delta y \bigg|_{y = 0} = (1 - \beta) / \alpha \quad \Delta q / \Delta y \bigg|_{q = 0} = \lambda_1 / (r + \theta)\]

That is, the lower is the marginal propensity to consume (out of income or wealth), the steeper is the \(y=0\) locus. Similarly, the higher the impact of output on dividends, the steeper the \(q=0\) locus.

The dynamic system just derived is represented in figure 1. The direction of the arrows of the dynamic system is derived as follows: From equations (2) and (5) we know that

\[\Delta q / \Delta q > 0 \quad \Delta y / \Delta y > 0\]

that is, the stock value has an "explosive" pattern: given other things constant, an increase in its value implies an upward adjustment. On the other hand, the level of output shows a stable behavior: the greater the increase in production, the lower the gap between production and the absorption level.

In figure 1, the behavior of the stock value is represented as follows. For any output level \(y\), if the stock value \(q\) is greater than its equilibrium value \(q=0\), the stock value increases, as demonstrated by the above relationship. Graphically, this behavior is shown by upside arrows for \(q>q=0\), and downside arrows for \(q<q=0\). On the other hand, the stability of output dynamics implies that, for any stock value, an output level greater than \(y=0\) induces a contraction in production. This is shown by leftside arrows; the arrows that point to the right represent then the inverse situation. Given the dynamics of each market, the movement towards equilibrium of the system is represented by the saddle path "sp".

From equation (7), it follows that an increase in either the price of the exportable good or in the foreign stock exchange index implies a shift of the \(q=0\) locus to the left. Of course, this shift will be larger the greater is \(\lambda_2\) or \(\lambda_3\) (for the case of the export price and the Dow Jones respectively) and/or the smaller is the real interest rate risk adjusted \((r+\theta)\). The external shock just described is represented in figure 2.
Initial equilibrium is depicted at point 1. A favorable external environment -originated either by an increase in the price of the main export good or by an increase in the Dow Jones index- affects only the stock market in the short run (point 2). In addition, the favorable news affect the output level in the medium run, what is shown by the saddle path from 2 to 3. Notice, however, that this new equilibrium is obtained only if the external effect is permanent. If those impacts are only transitory, the adjustment occurs in the financial but not in the real sector. Following the guideline of the last diagram, this is shown by a temporary movement from 1 to 2 with the final equilibrium returning to point 1. In other words, transitory movements of external variables cause a greater volatility in the domestic stock market.6

IV. THE LONG-RUN RELATIONSHIP OF THE DOMESTIC STOCK EXCHANGE AND EXTERNAL VARIABLES

As noted before, several studies have empirically tested the relationship between international stock markets. In some of them, however, a relationship is confirmed based on spurious correlation. The next charts plot the oil price and the Dow Jones index with the indice de la bolsa mexicana de valores for the Mexican case, and the price of copper and the Dow Jones index with the indice de la bolsa de comercio de Santiago in the Chilean case. Both domestic stock indices are expressed in dollar terms and all the variables refer to the 1985-1990 period. As might be easily confirmed, there seems to exist a similar pattern in all the variables. However, we need to test if these relationships are spurious or if they are indeed the result of a close influence. Engle and Granger (1987) showed that if a vector of variables is cointegrated, there exists a non-spurious, long-run relationship among them. It is precisely the cointegration technique the method that we apply to test if there exists an equilibrium relationship between the domestic stock index on the one hand and the price of the main export good and the Dow Jones stock

IV.1. Cointegration analysis.

In order to implement the cointegration technique to the domestic stock exchange index and the external variables selected, we first need to check out if these variables are stationary in first differences (integrated of order 1, I(1)).

6 In this context, it is extremely interesting to analyze the boom of the Mexican stock market in the third semester of 1987. This may be explained by a reduction in risk aversion among stock holders and, thus, a decrease in $\theta$ that implies both a shift and a change in slope of the $q=0$ line.
This is done implementing the augmented Dickey-Fuller test to the first difference of the series. The results are included in the appendix and show that each series accomplish the requirement of being a first difference stationary process. Once it is established the order of stationarity in the series, we estimate the cointegrating regression:

\[(8) \quad \text{stock}_t = a_0 + a_1 \text{dow}_t + a_2 \text{px}_t + e_t\]

with stock representing the national stock index expressed in dollars, dow the Dow Jones industrial index, px the price of the main export good of the country in reference and e the equilibrium error. If all the series are stationary of the same order -as was demonstrated above to be of order 1- the OLS estimation of (8) indicates the long-run or equilibrium relationship between the left hand side and right hand side variables. The results of the cointegrating regression for the 1985-1990 period as well as the cointegration tests are presented in Table 1.

**TABLE 1. COINTEGRATING REGRESSION**

<table>
<thead>
<tr>
<th></th>
<th>stock = a0 + a1 dow + a2 px + e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td>a1</td>
</tr>
<tr>
<td></td>
<td>0.359</td>
</tr>
<tr>
<td></td>
<td>(8.038)</td>
</tr>
<tr>
<td>Chile</td>
<td>0.452</td>
</tr>
<tr>
<td></td>
<td>(4.321)</td>
</tr>
</tbody>
</table>

Numbers in parenthesis are t statistics. DW is the Durbin Watson statistic; CRDW is the Durbin Watson test for the cointegrating regression. It is shown the critical value at the 95% confidence level (Engle and Yoo, 1987, Table 4). If the Durbin Watson obtained in the regression is smaller than this critical value, the non-cointegration hypothesis is not rejected. ADF is the t statistic for the augmented Dickey Fuller test applied to the equilibrium error:

\[(1-L) e_t = b_0 + b_1 e_{t-1} + b_2 (1-L)e_{t-1}\]

CV is the critical value of this statistic at the 90% confidence level (Engle and Yoo, 1987, Table 3). Similarly to the CRDW, if ADF is smaller than CV, we reject the hypothesis of non-cointegration.

The results reported in Table I seem to confirm that there exists a long run, equilibrium relationship of the Mexican stock exchange with the Dow Jones
index and with the price of oil: using the CRDW the null of no cointegration is rejected at the 95% confidence level, while the ADF test is just below the 90% confidence level. In the Chilean case, however, neither test can reject the null, suggesting that the Chilean bolsa is not cointegrated with the external variables selected.

Engle and Granger also demonstrate that cointegrated series have an error correction mechanism. The error correction model implies that a proportion of the disequilibrium between two time series in one period is corrected in the next period. Thus, the error correction model relates the change in the dependent variable—the change in the domestic stock exchange index—with past equilibrium errors—the lagged value of the error obtained in the cointegrating regression. The error correction model is expressed as

\[(9) \text{(1-L)} \text{ stock} = c_0 + c_1 c_{t-1} \]

L being the lag operator. The results of the error correction model are presented in Table II.

**TABLE II. ERROR CORRECTION MODEL**

\[(1-L) \text{ stock}_t = \alpha_0 + \alpha_1 e_{t-1} + \Sigma \beta_i x_{it-1} \]

Estimated values of \( \alpha_1 \)

<table>
<thead>
<tr>
<th>Mexico</th>
<th>Chile</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.3421</td>
<td>-0.081</td>
</tr>
<tr>
<td>(-3.322)</td>
<td>(-1.325)</td>
</tr>
</tbody>
</table>

L is the lag operator, stock is the national stock price index and 'e' is the equilibrium error of the cointegrating regression. t statistics are shown in parenthesis.

To prove cointegration through the error correction model in a bivariate model, it is required that the sum of the squared t-statistic of the \( c_1 \) coefficient plus the t-statistic of the inverse equation (with the explanatory variable now being the dependent one) be above the critical value of 11.0 (Engle y Granger, 1987, p.269). There are no tables to test the null of non-cointegration in the case of a multivariate model, as it is our case. However, the strong significance of the lagged error term in the equation for the Mexican stock market confirms the result of cointegration previously obtained. On the other hand, the lagged error term is significant in the Chilean error correction model, though much less than in the Mexican case, and the squared value of the statistic being below
the critical value, confirming, in some way, the non-cointegration result found above.

IV.2. Mexico's stock exchange reaction to permanent and transitory shocks.

Once that cointegration between the Mexican stock market and the external variables selected was confirmed, we follow to test if such relationship is due to permanent and stable shifts of the foreign variables or if it is due merely to transitory movements, usually associated with speculation. First, it is applied the decomposition technique suggested by Miller (1988) to each of the Mexican external series. According to this author, the permanent component (zt) of a time series zt is represented as

\[ Z_t = \Omega \left[ 1 - \sum \phi_i L^i / 1 - \sum \theta_i L^i \right] Z_t \]

with

\[ \Omega = \left[ 1 - \sum \phi_i / 1 - \sum \theta_i \right] \]

being \( q \) and \( f \) the moving average and autoregressive parameters respectively. These parameters are obtained by modeling the series \( zt \) as an ARIMA process. The results of the estimated model for the Dow Jones index and the price of oil are included in the appendix. In each case, the transitory component was computed as the difference between the actual and the estimated permanent series. Once the decomposition was obtained, the next regression was estimated

\[ \text{Stock}_t = \alpha_0 + \alpha_1 \text{dowp} + \alpha_2 \text{dowt} + \alpha_3 \text{poilp} + \alpha_4 \text{poilt} + \nu \]
The results obtained are reported in Table III.

**TABLE III. PERMANENT AND TRANSITORY EFFECTS OF EXTERNAL VARIABLES ON THE MEXICAN STOCK EXCHANGE**

\[
\text{stock } t = a_0 + a_1 \text{dowp} + a_2 \text{dowt} + a_3 \text{poilp} + a_4 \text{poilt} + v
\]

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a_1)</td>
<td>.394 (4.942)</td>
</tr>
<tr>
<td>(a_2)</td>
<td>.722 (4.464)</td>
</tr>
<tr>
<td>(a_3)</td>
<td>1.042 (.179)</td>
</tr>
<tr>
<td>(a_4)</td>
<td>1.149 (.440)</td>
</tr>
</tbody>
</table>

\[R^2 = .884\]  \[DW = 1.955\]  \[\text{rho} = .880 (9.15)\]

dowp= permanent component of the Dow Jones index
dowt= transitory component of the Dow Jones index.
poilp= permanent component of oil price.
poilt= transitory component of oil price.

Numbers in parenthesis are t-statistics, rho is the coefficient of the first order serial correlation of v.

These results suggest that even if the Mexican stock exchange index is cointegrated with both the Dow Jones index and the price of oil, its behavior is majorly influenced by the first variable. More interestingly, it is the transitory component of the Dow Jones index which has the strongest impact on the Mexican bolsa, what seems to indicate some speculative behavior in this market. Indeed, its coefficient is almost twice that of the permanent component of the Dow Jones. Thus, instrumenting policy actions to avoid the come and go pattern of some investors may reduce the market speculation and, hence, its volatility.

**V. CONCLUSIONS**

External shocks have a decisive influence on stock markets. This paper examined the relationship between the Chilean and Mexican stock index and two external variables: the Dow Jones index and the price of the main export good – copper in Chile and oil in Mexico. By implementing Engle and Granger’s cointegration technique, we show that there exists a long-run, equilibrium relationship of the Mexican stock index with the Dow Jones and the price of oil. The error correction model implemented for Mexico indicates
that higher than normal rates of return may be obtained in this market. In the Chilean case, however, the hypothesis of non-cointegration could not be rejected.

Once cointegration was found in the Mexican market, we demonstrated that the Mexican index has a closer relationship with the transitory component of the Dow Jones than with any of the other variables, indicating, thus, speculative movements in the Mexican bolsa. For this stock exchange, both the error correction model and the relationship with transitory movements of the Dow Jones indicate market inefficiency that can be considerably reduced by developing new financial instruments that enhance long-run investment.

APPENDIX

As mentioned above, testing cointegration requires that the variables to be cointegrated be stationary of the same order (greater than zero). Here we include the results of the augmented Dickey Fuller test to check first order stationarity of the Mexican and Chilean stock indexes, the Dow Jones, the price of oil and the price of copper. As noted, in all the variables the t-statistic of the lagged first difference is greater than the t=2.78 at the 90% confidence level (Dickey and Fuller, 1981), thus suggesting that each series is integrated of order 1 (I(1)).

\[(1-L)^2 x_t = d_0 + d_1 (1-L) x_{t-1} + (1-L)^2 x_{t-1}\]

<table>
<thead>
<tr>
<th></th>
<th>d0</th>
<th>d1</th>
<th>d2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexican stock</td>
<td>2.410</td>
<td>-0.906</td>
<td>0.258</td>
</tr>
<tr>
<td></td>
<td>(1.088)</td>
<td>(-6.493)</td>
<td>(2.220)</td>
</tr>
<tr>
<td>Chilean stock</td>
<td>5.633</td>
<td>-0.846</td>
<td>0.247</td>
</tr>
<tr>
<td></td>
<td>(2.306)</td>
<td>(-5.424)</td>
<td>(1.865)</td>
</tr>
<tr>
<td>Dow Jones</td>
<td>4.433</td>
<td>-0.709</td>
<td>0.262</td>
</tr>
<tr>
<td></td>
<td>(1.211)</td>
<td>(-5.721)</td>
<td>(2.248)</td>
</tr>
<tr>
<td>Price of Oil</td>
<td>0.003</td>
<td>-0.808</td>
<td>0.440</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(-6.298)</td>
<td>(3.314)</td>
</tr>
<tr>
<td>Price of Copper</td>
<td>1.365</td>
<td>-0.83</td>
<td>0.194</td>
</tr>
<tr>
<td></td>
<td>(0.753)</td>
<td>(-5.798)</td>
<td>(1.596)</td>
</tr>
</tbody>
</table>
ARIMA estimates.

Dow Jones ARIMA (2,1,0) $\phi_1 = 0.5533$ $\phi_2 = -0.2635$ Ljung-Box(20) = 19.07
Oil Price ARIMA (2,1,0) $\phi_1 = 0.6318$ $\phi_2 = -0.4405$ Ljung-Box(20) = 7.152
Figure 3
Mexico. Stock Index and Price of Oil

Figure 4

- for Figure 3: oil price - stock index
- for Figure 4: dow - stock index
Figure 5
Chile. Stock Index and Dow Jones

Figure 6
Chile. Stock Index and Price of Copper
BIBLIOGRAPHY


