Testing for Weak-Level Efficiency in the Secondary Market for Developing Country Debt

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Abstract

This paper investigates the presence of weak level efficiency in the secondary market for developing country debt by modeling as ARIMA processes debt price variations of eight large debtor countries that were actively traded during the period January 1986 to December 1992. The analysis suggests that in some cases the secondary market for developing-country debt was weakly inefficient and that there existed at least one trading rule capable of generating above-average returns. Moreover, the narrowing of above-average returns in the period following the announcement of the Brady Plan suggests that the secondary market for developing country debt became more efficient, possibly due to a reduction in default risk and an increase in the availability of timely investment information.

Introduction

The secondary market for developing country debt currently is one of the fastest growing segments of the fixed income securities market. From 1988 to 1992, for example, secondary market transaction volume of the ten most heavily indebted developing countries grew more than $150 billion, to nearly $200 billion.[1] The sharp increase in investor interest in developing country debt occurred contemporaneously with the promulgation of economic reform programs by many debtor governments to stimulate long-term economic growth and reduce external debt burdens, and the decline in U.S. interest rates. There are even developing country debt mutual funds available to individual investors, and Reuter's routinely publishes current bid and offer prices.

The Secondary Market for Developing Country Debt

The formidable external debt burden of many developing countries has been the subject of intense analytical scrutiny since 1982 when Mexico's finance minister, Jesus Silva Herzog, suspended principal repayments on Mexico's official international commercial bank debt. This action marked the onset of what came to be known as the international debt crisis.[2] Largely in response to the promulgation of debt-for-equity swaps offered by debtor countries to reduce dollar-denominated foreign commercial bank debt, which was preceded by commercial banks' portfolio adjustment and widespread dumping of debt paper, an active secondary market for developing country debt evolved.

Until 1989, the exotic and illiquid nature of these instruments resulted in relatively low trading volume. This changed in mid-1989 when several money-center commercial banks set aside substantial reserves against developing country loan losses. These actions suggested that commercial bankers were prepared to become net sellers of developing country debt. The result was a sharp increase in trading volume and a dramatic increase in discounts on the debt.

In order to avoid the chronic rescheduling episodes that plagued the debt management process, large money-center commercial banks began to securitize developing country loans into more easily tradable bonds. The resulting sharp increase in trading volume was given additional impetus in March 1989 when U.S. Treasury Secretary Nicholas Brady announced that financial support from multinational institutions and the government of Japan would be mobilized to negotiate reductions in loan principal and debt service.

Although the idea of voluntary or market-based debt reduction was part of the menu approach proposed in 1985 by U.S. Treasury Secretary James Baker, which encouraged such market-based approaches as debt-for-equity and debt-for-bond swaps, the Brady Plan called on the World Bank and the IMF to make loans that would enable debtor governments to negotiate debt-reduction agreements with commercial banks. With these funds as collateral, debtors could exchange their debt to foreign commercial bankers at a discount for new bonds or at par for bonds carrying reduced rates of interest, or both. Many of these loans were converted into "Brady bonds" in which the principal was secured by zero-coupon U.S. Treasury bonds. Despite the fact that a significant portion of developing country debt was "restructured" into bonds backed by the U.S. Treasury guarantees, secondary market prices continued to be characterized by extreme volatility.

Efficient Capital Markets

Much of the research into the secondary market for developing country debt was concerned with identifying the determinants of the secondary market discounts. Boehmer and Megginson (1990), Purcell and Orlanski (1988, 1990), and Webster (1992) fall into this category. Purcell *et al.* (1990) also have made excellent arguments for investing in these instruments. Very little research, however, has been done on the returns to holding developing country debt.

There is a substantial body of literature on the relationship between asset yield and market efficiency. The literature identifies three levels of market efficiency (weak, semi-strong, and strong) and is concerned with specific assumptions about the information set available to investors and the manner in which market prices are established (Fama, 1970). The purpose of this paper is to test whether the secondary market for developing country debt was weakly efficient by examining price variations for eight heavily indebted developing countries (Argentina, Brazil, Chile, Mexico, the Philippines, Venezuela, Ecuador, and Colombia) for the period January 1986 to December 1992.

A market is weakly efficient if contemporaneous securities prices fully reflect all information implied by prior price movements. In weakly efficient markets, current prices respond instantaneously and without bias to new information, which implies the absence of price regularities with prophetic significance. Markets that are weakly efficient are described by the process

$$P_t = P_{t-1} + \xi_t \tag{1}$$

where P_t is the market price in period t, and P_{t-1} is the price in period t-1. The random error term ξ_t is sometimes referred to as "white noise," where $E(\xi_t)=0$ and $E(\xi_t \xi_{t-i})=0$. Equation (1) is known as a "random walk." It says that the best estimate of the current price of a security is the price that prevailed in the previous period. A variation of this process is

$$P_t = \zeta + P_{t-1} + \xi_t \tag{2}$$

where ζ is a constant parameter, which is known as a "random walk with drift."

Statistical Tests

To test the hypothesis that the secondary market for developing country debt was weakly efficient, secondary market price variations were modeled as ARIMA (autoregressive integrated moving-average) processes. ARIMA models, which have been successfully used to represent the behavior of stationary time series, are described by the expression:

$$(1-\phi_1 B-\phi_2 B^2-\dots-\phi_p B^p)(1-B)^d(P_t-\mu)=(1-\theta_1 B-\theta_2 B^2-\dots-\theta_q B^q)\xi_t \tag{3}$$

where B is a backshift operator and $P-\mu$ is the secondary market price expressed as a deviation from its mean (Pankratz, 1983). Equation (3) is called a mixed process because it contains both autoregressive and moving-average components. The autoregressive and moving-average components are denoted as $(1-\phi_1 B-\phi_2 B^2-\dots-\phi_p B^p)$ and $(1-\theta_1 B-\theta_2 B^2-\dots-\theta_q B^q)$, respectively.

Stochastic models of time series implicitly assume regularity in the underlying generating process, i.e. a stationary time series. A condition that is sometimes present in time series data is "nonstationarity," which may exhibit a number of properties, including a systematic change mean or variance, or seasonal or periodic variations. The probability theory of time series analysis primarily concerns itself with processes that exhibit constant mean and variance.

To explain the variation of a time series as an ARIMA process it is necessary to transform a nonstationary time series into a stationary time series, which is sometimes accomplished by performing log transformations or first differencing the data. The expression $(1-B)^d$ in equation (3) is a differencing operator.

The order of the process is typically represented as ARIMA (p,d,q). If the time series also contains seasonal or periodic components then the process is nonstationary and the order conditions must be modified as

ARIMA $(p,d,q)(P,D,Q)$, which is generalized as

$$(1-\phi_1 B-\phi_2 B^2-\cdots-\phi_p B^p)(1-\Phi_1 B^s-\cdots-\Phi_P B^{Ps})(1-B)^d(1-B^s)^D(P_t-\mu)$$
$$=(1-\theta_1 B-\theta_2 B^2-\cdots-\theta_q B^q)(1-\Theta_1 B^s-\cdots-\Theta_q B^{Qs})(1-B)^d\xi_t \qquad (4)$$

Not all time series processes contain autoregressive or moving-average components. If this condition is satisfied, an ARIMA (0,1,0) process reduces equation (3) to equation (1) , i.e., a "random walk" (with or without drift), which would suggest a weakly efficient market.

Modeling a time series as an ARIMA process typically involves three phases: identification, estimation, and diagnostics. The identification phase, which involves determining stationarity and the order of the time series process, is largely accomplished by examining the corresponding autocorrelation (acf) and partial autocorrelation (pacf) functions. Once the order conditions have been identified, parameter values are then estimated.

In the diagnostic phase, if the selected models are specified correctly, the error terms, ξ_t , will be "white noise," i.e all autocorrelations will be zero. The test statistic for white noise, which was suggested by Ljung and Box (1978), is given by the expression

$$\chi^2_m=n(n+2)\sum_{k=1}^{m}\left[\frac{r_k^2}{(n-k)}\right] \qquad (5)$$

where m is the number of residual autocorrelations, r_k. If m is moderately large and the model is correctly specified, then χ^2_m has a distribution close to chi-square with $(m-p-q)$ degrees of freedom. The hypothesis that the model is specified incorrectly is rejected for values of χ^2_m exceeding the upper tails of a chi-square distribution.

Data

Much of the empirical research into market efficiency has been concerned with well-established, well-organized, and impersonal markets, such as the New York Stock Exchange. By contrast, transactions in the secondary market for developing country debt largely have been negotiated. Lax reporting requirements, however, and a reluctance by market-makers to reveal proprietary information, have made detailed information about transactions difficult to obtain. Developing country loan discounts, therefore, represent the primary source of secondary market information.

To test whether the secondary market for developing country debt was weakly efficient, price variations for eight heavily indebted developing countries (Argentina, Brazil, Chile, Mexico, the Philippines, Venezuela, Ecuador, and Colombia) were examined for the period January 1986 to December 1992. Average monthly secondary market developing country debt prices, expressed as a fraction of par value, were obtained from *Emerging Markets Updates* published by Morgan Guaranty Trust Company.

Empirical Results

Table 1 presents the order conditions of ARIMA processes for the eight Latin American debtors examined in this paper. Parameter estimates (presented in Table A1 in the appendix) were generated using the maximum likelihood technique discussed in Ansley (1979). To facilitate the choice of the best ARIMA model, the Akaike Information Criterion (AIC) also was estimated for each model. In general, the value of p is chosen that yields the smallest AIC. These values reflect the fitted autoregressive models' closeness of fit to the data given the number of parameters estimated. The χ^2_m statistic for the first 12 and 24 residual correlations presented in Table 1 would not lead us to seriously question the adequacy of the estimated models.

The results presented in Table 1 suggest that the secondary market for developing country debt was weakly efficient in the cases of Argentina and Mexico. In both cases, the order condition for weak level efficiency (ARIMA (0,1,0)) were satisfied. Argentina and Mexico also exhibited seasonal or periodic variations, which were neither autoregressive or serially correlated in nature, but are the result of factors that are exogenous to the underlying process. The results presented in Table 1 also suggest that the secondary market for developing country debt was weakly inefficient in the cases of Brazil, Chile, Colombia, Ecuador, the Philippines, and Venezuela.

Secondary Market Inefficiencies and Trading Rules: An Illustration

The distinguishing characteristic of markets that are weakly efficient is that they rule out the possibility of trading rules that can exploit correlated regularities in past price movements to generate above-average returns. The results presented in Table 1 suggest, however, that it should have been possible to out perform the market by adopting an appropriate investment strategy.

To illustrate this assertion, suppose that the following simple investment strategy was adopted.[3] Assume

Table 1
Estimated Values of AIC and χ^2_p for ARIMA Models Fitted to Secondary Market Developing Country Debt Prices--January 1986 to December 1992

Country $(p,d,q)(P,D,Q)_s$	AIC	χ^2_{12}	(df)	χ^2_{24}	(df)
Argentina $(0,1,0)(0,1,1)_4$	383.64	12.10	(11)	19.51	(23)
Brazil (0,1,1)	425.54	11.35	(11)	26.45	(23)
Chile $(0,2,1)(0,0,1)_6$	386.00	5.06	(10)	10.76	(22)
Colombia (1,1,0)	390.11	5.44	(11)	18.58	(23)
Ecuador (0,1,2)	391.09	5.89	(10)	21.28	(22)
Mexico $(0,1,0)(1,1,1)_3$	433.51	11.06	(10)	21.19	(22)
Philippines (0,1,1)	394.97	10.59	(11)	26.97	(23)
Venezuela (1,1,0)	387.85	8.56	(11)	19.04	(23)

that developing country debt prices were realized at the end of each time period. An investor purchases a given dollar amount of developing country debt in the period following a positive percentage "up-tick" in the price, and sells in the period following a percentage "down-tick." The process is repeated following the next "up-tick" with the full amount of the previously realized earnings reinvested.

This illustration assumes that the security pays no explicit interest (although it is expected that interest payments are reflected in price variations), and that there are no transactions costs. The results of this investment strategy, which are presented in Table 2, are compared with the compounded annual monthly returns that would have been earned had the investor held initial purchase throughout the entire investment period. Also included in the table are the mean absolute difference (MAD), the root mean squared difference (RMSD), and estimated t-statistics to test the hypothesis that the compounded annual monthly returns without an investment strategy are significantly different than the returns generated using the above investment strategy.

The results presented in Table 2 support the results presented in Table 1. Although in each case the investor would have outperformed the market employing the investment strategy outlined above, the differences in returns are statistically insignificant at traditional one-tailed confidence levels in the cases of Argentina and

Table 2
Compounded Annual Monthly Returns on Secondary Market Developing Debt With and Without an Investment Strategy (Percent)--January 1986 to December 1992

Country	Without Strategy	With Strategy	Difference	t-statistic
Argentina	0.155	1.202	1.047	0.715
Brazil	-0.917	1.861	2.778	2.169
Chile	0.556	2.027	1.471	3.090
Mexico	0.143	0.314	0.171	0.120
Philippines	-0.153	2.538	2.691	3.382
Venezuela	-0.308	1.773	2.081	3.138
Ecuador	-0.726	1.267	1.993	1.525
Colombia	0.142	1.592	1.450	3.008
MAD			1.710	
RMSD			1.893	

Table 3
Compounded Annual Monthly Returns on Secondary Market Developing Country Debt With and Without an Investment Strategy (Percent)--January 1986 to February 1989

Country	Without Strategy	With Strategy	Difference
Argentina	-5.916	-3.655	2.261
Brazil	-3.764	-2.553	1.211
Chile	-0.252	1.480	1.732
Mexico	-2.384	-1.954	0.430
Philippines	-2.151	0.118	2.269
Venezuela	-3.492	-1.996	1.496
Ecuador	-9.976	-3.364	6.612
Colombia	-1.496	-0.653	0.843
MAD			2.107
RMSD			2.774

Mexico.

As an additional test for the presence of weak-level secondary market efficiency, investment returns with and without the investment strategy outlined above were calculated for the sub-periods January 1986 to February 1989 and March 1989 to December 1992. The reason for this particular division of the data set is straightforward. Prior to the announcement of the Brady Plan in March 1989, the secondary market for developing country debt, which was dominated by a few large multinational corporations, was characterized by relatively low trading volume. In 1985, for example, only about $6 billion of US$700 billion in medium- and long-term developing country debt was traded in the secondary market, either through debt-for-equity swaps or by debtor countries repurchasing their debt at a discount.

After the announcement of the Brady Plan, and the introduction of Brady bonds a month later in connection with Mexico's renegotiating $53 billion in medium- and long-term debt to foreign banks, the secondary market for developing country debt became more attractive and accessible to smaller investors. The result was broader market participation and an increase in the availability of information about the quality of debt instruments, which suggests that the secondary market probably became more efficient after the March 1989 announcement.

The investment results presented in Tables 3 and 4 suggest that, in general, investment returns as measured by the mean absolute difference and the root mean squared difference narrowed over the two sub-periods examined. These statistics suggest that while the secondary market for developing country debt probably was inefficient in both investment periods examined, it appears to have become more efficient following the announcement of the Brady Plan, probably because of a reduction in default risk associated with the introduction of Brady bonds.

Conclusion

This paper examined the "weak" form of market efficiency for debt instruments of eight large debtor countries that were actively traded in the secondary market for developing country debt during the period January 1986 to December 1992. The evidence seems to suggest that the secondary market was weakly efficient in the cases of Argentina and Mexico and weakly inefficient in the cases of Brazil, Chile, the Philippines, Venezuela, Ecuador, and Colombia.

The paper also demonstrates that in the presence of secondary market inefficiencies there existed at least one trading rule capable of generating above-average returns. Moreover, the narrowing of above-average returns in the period following the announcement of the Brady Plan suggests that the secondary market for developing country debt probably became more efficient, perhaps due to a reduction in default risk associated with the introduction of Brady bonds. This innovation not only broadened market participation and dispersed market power, but reduced investment uncertainty due to the increased availability of timely investment information.

Table 4
Compounded Annual Monthly Returns on Secondary Market Developing Country Debt With and Without an Investment Strategy (Percent)--March 1989 to December 1992

Country	Without Strategy	With Strategy	Difference
Argentina	6.637	5.346	-1.291
Brazil	0.731	3.243	2.609
Chile	1.444	2.540	1.096
Mexico	2.103	0.861	-1.242
Philippines	1.472	3.103	1.631
Venezuela	1.844	2.378	0.534
Ecuador	4.663	4.660	-0.003
Colombia	1.609	2.419	0.810
MAD			1.152
RMSD			1.852

Suggestions for Future Research

The analysis presented in this paper suggests that the secondary market for developing country debt probably was weakly inefficient in six of the eight cases examined for the entire sampling period. The announcements of the Baker and Brady Plans, and the subsequent introduction of Brady bonds, however, probably resulted in structural changes in the secondary market, which would imply parametric changes in the underlying generating process. This possibility is illustrated in Table 5, which summarizes the standard deviations of average annual monthly returns on investments in secondary market developing country debt during each of the periods examined. With the exception of Chile, standard deviations for secondary market returns increased significantly after the announcement of the Brady Plan, which suggests that investments in these instruments became riskier, perhaps due to an increase in speculative trading activity. An investigation into the

Table 5
Comparative Standard Deviations of Secondary Market Developing Country Debt Returns Before and After the Announcement of the Brady Plan

Country	January 1986 - December 1992	January 1986 - February 1989	March 1989 - December 1992
Argentina	11.676	6.063	14.331
Brazil	9.478	5.112	11.896
Chile	3.927	5.091	2.518
Mexico	6.694	5.242	7.408
Philippines	5.826	4.122	6.751
Venezuela	5.119	4.444	5.159
Ecuador	9.913	8.838	9.875
Colombia	3.837	3.068	4.127

possibility of structural changes in secondary market trading activity, and the implications for weak-level efficiency warrant further investigation.

✻✻✻Endnotes✻✻✻

1. Developing country debt primarily represents troubled or nonperforming commercial bank loans made primarily to Latin American countries in the wake of the first and second oil price shocks of the mid- and late-1970s.
2. The belief that this crisis threatened the stability of the international financial system led to a number of innovative debt reduction schemes, including debt-for-equity swaps, debt-for-debt exchanges, debt buy-backs, and debt-for-bond swaps.
3. Although the simple trading rule adopted here is a concoction of the author, any trading rule that is based on prior period price information should be able to generate above-average returns if the market is weakly inefficient. In fact, more exotic or time varying trading rules that more fully exploit the autoregressive or moving-average characteristics of the underlying process should generate greater returns.

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Table A1
Final ARIMA Parameter Estimates*

Argentina (0,1,0)(0,1,1)$_4$	$(1-B)(1-B^4)(P_t+0.064) = (1-0.743B^4)\xi_t$ [0.084]
Brazil (0,1,1)	$(1-B)(P_t+0.575) = (1+0.276B)\xi_t$ [0.107]
Chile (0,2,1)(0,0,1)$_6$	$(1-B^2)(P_t-0.616) = (1+0.984B)(1+0.230B^6)\xi_t$ [0.063] [0.108]
Colombia (1,1,0)	$(1-0.258B)(1-B)(P_t-0.054) = \xi_t$ [0.107]
Ecuador (0,1,2)	$(1-B)(P_t+0.523) = (1+0.283B+0.281B^2)\xi_t$ [0.108] [0.110]
Mexico (0,1,0)(1,1,1)$_3$	$(1+0.247B^3)(1-B)(P_t-0.129) = (1-0.936B^3)\xi_t$ [0.092] [0.110]
Philippines (0,1,1)	$(1-B)(P_t+0.224) = (1+0.261B)\xi_t$ [0.108]
Venezuela (1,1,0)	$(1-0.249B)(1-B)(P_t+0.277) = \xi_t$ [0.108]

*Numbers in brackets are estimated standard errors.

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