

Emerging Market Efficiencies: New Zealand's Maturation Experience in the Presence of Non-Linearity, Thin Trading and Asymmetric Information

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ABSTRACT

This paper examines the efficiency of New Zealand's stock market by assessing the prevalence of thin trading, non-linearity and information asymmetry. We find that the efficiency of this emerging market has been enhanced over time due to regulatory changes and the transition of the New Zealand economy to a free market orientation. During the 1970s and 1980s, the stock market appears to have been inefficient with thin trading and non-linearity as leading causative agents. Our evaluation of non-linear models, adjusted for thin trading effects, however, strongly suggests that the New Zealand stock market has become more efficient since 1990.

I. INTRODUCTION

New Zealand experienced profound structural changes in its overall economy and in its equities exchange markets during the 1980s. The country moved from being one of the most economically regulated societies at the end of the 1970s to one of the least regulated countries by the beginning of the 1990s. The New Zealand stock market experienced significant change as it consolidated into one national market from regional trading floors on June 24, 1991. The exchange introduced its 'FASTER' electronic transfer system on August 1, 1992 and moved to fully automated clearing and settlement of trades on May 18, 1998. The Exchange installed a new modernized trading and settlement platform to replace the initial screen trading system in September 1999. Despite considerable efforts to consolidate and modernize, however, the New Zealand stock market remains small and lacks sufficient market making activity to ensure the

liquidity requisite to market efficiency. We examine the evolving efficiency of the New Zealand stock market in this paper.

Much of the controversy on the issue of testing for market efficiency arises because thin or infrequent trading introduces serious bias in observed returns. Recently, Solibakke (2001) investigated the effects and consequences of such thin trading. He shows that bias in the estimated efficiency of infrequently traded emerging market stocks can be caused by recorded prices that represent transactions that occurred before the record period. In essence, one trade may be reflected as several successive day's price reports, inducing serial correlation in the time series of returns.

Studies examining equity market efficiency are generally designed to employ tests of the efficient market hypothesis (EMH). EMH tests assume that stock returns are generated by linear processes. In reality, stock returns may exhibit substantial non-linearity due to feedback mechanisms in price movements, market imperfections, and the structure of particular equities markets. In less developed markets, efficiency tests based on linear models may lead to unreliable empirical results. Indeed, researchers have observed non-linearity in both developed and emerging stock markets due to regulatory changes, thin trading, unreliable information, overreaction, high transaction costs, and the effects of inside information (e.g. Koutmos 1992; Sewell et al. 1993 among others). More recently, Solibakke (2001) has argued that non-trading effects as well as non-linear volatility clustering may contribute significantly to the dynamics of asset pricing in thinly traded emerging stock markets.

Trading volumes and trade frequency of New Zealand stock market issues are, in many cases, lower than issues trading in more developed markets, leading to less rapid incorporation of new information into prices. Thin trading may also induce biases to the moments of return series due to irregular recording intervals, which spawn spurious autocorrelation. To accommodate these data imperfections, we performed only weak-form market efficiency tests for the New Zealand stock market, simultaneously considering non-linearity, thin trading and structural market changes. To account for non-linearity in the generating process of stock index returns, we first employed a logistic map equation, which considers non-linear behavior in the New Zealand stock index, but does not require specification of the exact nature of the non-linearity. We also employed GARCH-M and exponential GARCH (EGARCH) models to examine volatility clustering and leverage effects in the New Zealand market.

II. PRIOR RESEARCH

The market efficiency hypothesis (EMH) has been a very active area of financial markets research for many years. Studies have often focused on the degree of efficiency prevailing in a particular market and numerous researchers have identified market inefficiencies, commonly referred to as *anomalies*. Autocorrelation effects (Lo and MacKinlay 1988; Fama and French 1988), the small-firm

effect (Banz 1981), the January-effect (Keim 1983), profitability assessment of return-reversal or contrarian strategies (DeBondt and Thaler 1985) and analyses of momentum strategies (Jegadeesh and Titman 1993) have all supported notions of less than perfect efficiency.

The research conclusions from market efficiency tests of national equity markets, however, are mixed. For equities markets in highly developed countries, Cootner (1962) and Fama (1965) found support for weak-form efficiency and the random behavior of stock prices that efficiency implies. Lo and Mackinlay (1988), on the other hand, found evidence of non-random stock price behavior.

In studies of emerging stock markets, researchers have focused on whether the markets efficiently incorporate newly arriving information or whether anomalies exist. The empirical results on market efficiency for emerging markets are also inconclusive. Dickinson and Muragu (1994) find support for weak-form efficiency in emerging equity markets despite acknowledged problems of non-linearity and thin trading. However, El-Erian and Kumar (1995) and Antoniou and Ergul (1997) find evidence to reject market efficiency, arguing that inefficiency in emerging markets might be attributed to delays in transaction posting, high transaction costs, thinness of trading and illiquidity.

III. DATA AND METHODOLOGY

Daily closing index returns, R_t , were calculated using the first log difference for daily price indices for the New Zealand stock market.

$$R_t = \ln(P_t/P_{t-1}) \quad (1)$$

where P_t and P_{t-1} represent the current and the previous daily market price index. The index data are the Barclays index from January 5, 1970 to June 27, 1991, and its successor, the NZSE-40 capital index from June 28, 1991 through March 31, 2004. The NZSE-40 capital index is a capitalization-weighted price index that includes the 40 largest and most liquid stocks traded on the New Zealand stock exchange.

A. Correcting for thin trading and non-linearity of stock prices

To investigate the efficiency of the New Zealand stock market we explicitly consider factors that have been shown to be influential in studies of other emerging markets. To account for possible non-linearity in the NZSE-40 capital index returns we employ a logistic map equation that addresses the non-linear behavior but does not require specification of the exact nature of the non-linearity:

$$R_t = \alpha_0 + \alpha_1 R_{t-1} + \alpha_2 R_{t-1}^2 + \alpha_3 R_{t-1}^3 + \xi_t \quad (2)$$

where R_t is the NZSE-40 capital index return at time t . If a market is to be deemed to be informationally efficient, all of the coefficients estimated for equation (2)

should be statistically indistinguishable from zero ($\alpha_0 = \alpha_1 = \alpha_2 = \alpha_3 = 0$) and the residual terms, ξ_t , should follow a white noise process.

We also adapt the methodology of Miller et al. (1994) to correct for thin trading. In order to address the thin trading effect we first posit a moving average model (MA) with sufficient terms to reflect the number of non-trading days and anticipate adjusting the raw returns accordingly. Given the difficulties in identifying the appropriate number of non-trading days, however, Miller, et al. proposed an equivalent first order autoregressive model AR(1) from which an appropriate thin-trading adjustment could be estimated. We follow their parsimonious specification and adopt this AR (1) transformation:

$$R_t = \alpha_0 + \alpha_1 R_{t-1} + \varepsilon_t. \quad (3)$$

Using the residuals from equation (2), the adjusted return is estimated as:

$$R_t^{\text{adj}} = \frac{\varepsilon_t}{1 - \alpha_1} \quad (4)$$

where R_t^{adj} is the return at time t adjusted for thin trading. Miller et al. found that this thin trading adjustment reduced the undesirable negative correlations among successive return observations. The model above assumes that the appropriate adjustment for non-trading is constant over time. This assumption may be correct for highly liquid markets, but it is not likely adequate for emerging stock markets undergoing structural changes. Indeed, it is likely inadequate for our study of New Zealand's stock market. Therefore, equation (3) will be estimated recursively. In testing for efficiency, equation (2) is estimated using corrected returns calculated recursively from equation (4). Moreover, efficiency will be examined using both linear and non-linear models to gauge the impact of model refinement on the results. We also examine the New Zealand stock market over time to assess structural changes. Hence, the models will be estimated on an annual basis using daily NZSE-40 capital index prices and returns.

B. Addressing volatility clustering and the effects of leveraging

We also examined the possible effects of volatility clustering and leverage in the New Zealand market returns data. GARCH-M and EGARCH-M models are appropriate for this examination. This class of models allows the simultaneous estimation of both central tendency and volatility parameters in returns data. If the New Zealand stock market were efficient, the NZSE-40 capital index returns would not be predictable based upon their previous volatilities or return levels. Accordingly, after adjusting returns for thin trading across several sub-periods, we estimate the GARCH models and interpret their market efficiency parameter estimates. We also explicitly include time-varying volatility, h_t , in the mean equations for the GARCH and EGARCH models to investigate whether the New Zealand stock market has compensated over time for its own risks as measured by conditional volatility.

The mean and variance equations of the GARCH-M (1, 1) model are specified as:

$$\begin{aligned} R_t^{\text{adj}} &= u_1 + u_2 R_{t-1}^{\text{adj}} + u_3 R_{t-1}^{2,\text{adj}} + u_4 R_{t-1}^{3,\text{adj}} + \delta_1 h_t + \varepsilon_t \\ h_t &= \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} \end{aligned} \quad (5)$$

where δ_1 is the risk premium, and ε_t is assumed to be normally distributed with zero mean and conditional variance $h_t = \sigma_t^2$. Similarly, for corrected returns, we estimate the following EGARCH-M (1, 1) model to capture asymmetric leverage effects between the NZSE-40 capital index returns and their conditional volatility:

$$\begin{aligned} R_t^{\text{adj}} &= u_1 + u_2 R_{t-1}^{\text{adj}} + u_3 R_{t-1}^{2,\text{adj}} + \delta_1 h_t + \varepsilon_t \\ \log h_t &= \alpha_0 + \alpha_1 \frac{|\varepsilon_{t-1}|}{h_{t-1}} + \gamma_1 \frac{\varepsilon_{t-1}}{h_{t-1}} + \beta_1 \log h_{t-1} \end{aligned} \quad (6)$$

where δ_1 is the risk premium and γ_1 is a leverage coefficient. The models are estimated for the NZSE-40 capital index using the Berndt et al. (1974) maximum likelihood method (BHHH). In our EGARCH-M (1, 1) framework, if $\gamma_1 \neq 0$, we can conclude that there exist asymmetric effects on conditional volatility. Weak-form efficiency requires that all information about past returns has been fully reflected in current returns, implying that $u_j = 0$ for $\forall j$. Thus, our attention is focused on the estimates of u_j when testing the lowest hurdle of weak-form EMH. The coefficients (α_1 and β_1) of the conditional volatility equations are crucial when assessing higher hurdle weak-form efficiency.

C. Testing weak-form market efficiency of the New Zealand stock market

Our first test of efficiency of the New Zealand stock market is a serial correlation test. One of the most direct and intuitive tests of the random walk hypotheses (RWH) for an individual time series is to check for serial correlation between two observations of the same series at different dates. Under the weakest version of the random walk, the increments or first-differences of the level of the random walk are uncorrelated at all leads and lags. Therefore, we may test the weak form of efficiency by testing the null hypothesis that the autocorrelation coefficients of the first differences at various lags are not statistically different from zero.

Our second test is to gauge the possible presence of non-linearity in the NZSE-40 capital index returns. To affect this test, equation (2) will be estimated over several sub-periods and the consistency of the estimates over time will be assessed.

Third, after adjusting for thin trading by the methods of Miller et al. (1994) and Antoniou and Ergul (1997), equations (2) and (3) will be re-estimated. Fourth, to trace the development of efficiency of the market over time, the procedures will be applied to each annual data set. If the New Zealand market is efficient, we expect α_1 , α_2 , and α_3 (the coefficients of the lagged index return and

Table 1 Random walk model without non-linearities for the NZSE-40 capital index returns

Sub-Periods	α_0	α_1	Ljung-Box Q
<i>Panel A: The linear model for uncorrected index returns</i>			
1 – (January 1970–December 1979)	0.0000 (1.1558)	0.3198 (17.2508)	54.0940
2 – (January 1980–December 1989)	0.0005 (2.7408)	0.1393 (7.1825)	196.5190
3 – (January 1990–December 1999)	0.0000 (0.1947)	0.3431 (1.7537)	51.2174
4 – (January 2000–March 2004)	0.0000 (0.3027)	–0.0346 (–1.1342)	37.8930
<i>Panel B: The linear model for corrected index returns to adjust for thin trading</i>			
1 – (January 1970–December 1979)	0.0000 (0.7574)	0.3283 (17.1744)	181.3620
2 – (January 1980–December 1989)	0.0006 (2.9179)	0.1358 (6.9396)	205.9900
3 – (January 1990–December 1999)	0.0000 (0.2228)	0.0286 (1.4673)	52.3471
4 – (January 2000–March 2004)	0.0000 (0.3471)	–0.0414 (–0.0414)	37.3440

The *t*-statistics are reported in parenthesis. The results of Ljung-Box Q test statistics for the residuals up to 52 lags are reported in the last column.

non-linear terms) in equation (2) not to be significantly different from zero. Both the Ordinary Least Square (OLS) and the Generalized Method of Moment (GMM) techniques are used to estimate the coefficient parameters. Among the OLS assumptions is the requirement that error terms are cross-sectionally uncorrelated and homoskedastic. Because we expect that the error terms may indeed be heteroskedastic the OLS approach has a potential specification error. The GMM framework, on the other hand, can be used to derive homoskedastic-consistent standard errors. Furthermore, the GMM technique is helpful when error terms deviate from normality and serial independence. Coefficients estimated with each technique are reported and assessed.

IV. EMPIRICAL RESULTS

Panel A of Table 1 reports the coefficient estimates of the linear model in equation (3) for uncorrected NZSE-40 capital index returns using both the OLS and GMM techniques for the sub-periods. From the coefficient of lagged returns (α_1) using the uncorrected NZSE-40 capital index returns, we can reject the null hypothesis of market efficiency at any conventional significance level for the 1970s and 1980s. However, we cannot reject the null hypothesis for the 1990s and 2000s. It appears that the New Zealand stock market was informationally inefficient in the weak-form sense during the initial decades, but has become

Table 2 Random walk model with non-linearities for the NZSE-40 capital index returns

Sub-Periods	α_0	α_1	α_2	α_3
<i>Panel A: The non-linear model for uncorrected index returns</i>				
1 – (January 1970–December 1979)	0.0000 (– 0.6493)	0.4902 (22.1838)	3.1649 (2.7272)	– 623.3550 (– 13.2761)
2 – (January 1980–December 1989)	0.0000 (2.4986)	0.2473 (11.3212)	– 0.9608 (– 1.5828)	– 32.5384 (– 6.7454)
3 – (January 1990–December 1999)	– 0.0000 (– 0.3370)	0.1239 (5.8821)	0.7437 (1.3172)	– 43.0999 (– 8.0529)
4 – (January 2000–March 2004)	– 0.0001 (– 0.5049)	0.0238 (0.6228)	2.8673 (1.2404)	– 99.8348 (– 1.4788)
<i>Panel B: The non-linear model for corrected returns to adjust for thin trading</i>				
1 – (January 1970–December 1979)	– 0.0001 (– 1.9428)	0.3996 (17.3938)	4.0302 (3.3474)	– 648.4760 (– 13.1423)
2 – (January 1980–December 1989)	0.0004 (2.0786)	0.1567 (7.0230)	– 1.5806 (– 2.8990)	– 40.8062 (– 8.7393)
3 – (January 1990–December 1999)	– 0.0002 (– 1.4609)	– 0.0127 (0.6062)	1.2477 (2.6733)	– 37.6912 (– 8.5514)
4 – (January 2000–March 2004)	– 0.0001 (– 0.7408)	0.0544 (1.4245)	3.1024 (1.2891)	– 107.5582 (– 1.4989)

The *t*-statistics are reported in parenthesis.

weak-form efficient since 1990. Modernization and consolidation of the New Zealand stock exchanges are likely explanations.

The Ljung and Box *Q*-test results in Panel A of Table 1 show that the serial correlation between the returns and the lagged returns for up to 52 lags are statistically significant. This serial correlation test also implies that the New Zealand stock market was informationally weak-form inefficient over the early periods studied, but improved in efficiency after 1990.

Thin trading has been a defining characteristic of the New Zealand stock market and studies of the market's efficiency risk the drawing of erroneous conclusions if this phenomenon is not taken into account. We adjusted the New Zealand market data for thin trading effects using the linear model and report the results in Panel B of Table 1. In the first two decades the coefficients for lagged returns were significant implying market inefficiency. In the 1990s and 2000s the coefficients are not statistically significant, lending support to the efficiency hypothesis. Again, the Ljung and Box *Q* statistics support these conclusions.

To allow for possible non-linearity in the return generating process that might affect the efficiency of the New Zealand stock market, we also incorporated lagged and non-linear terms into the model. Panel A of Table 2 shows the estimation results obtained when the non-linear model in equation (2) was applied. Before the 2000s, several non-intercept coefficients are significantly different from zero. Based on the results for the uncorrected data,

Table 3 Random walk test on a yearly basis without non-linearities for adjusted NZSE-40 capital index returns

Year	α_0	α_1
1970	-0.0003 (-1.1333)	0.2890 (4.7001)
1971	-0.0000 (-0.0926)	0.3665 (6.0985)
1972	0.0004 (2.2420)	0.5742 (10.2782)
1973	-0.0000 (-0.0606)	0.2446 (3.9956)
1974	-0.0005 (-1.2567)	0.3805 (6.3687)
1975	0.0003 (0.8100)	0.2412 (3.9163)
1976	0.0001 (0.5144)	0.2670 (4.3598)
1977	0.0000 (-0.1867)	0.4001 (6.7119)
1978	0.0003 (2.0052)	0.3638 (6.0420)
1979	0.0003 (1.4098)	0.3399 (5.6287)
1980	0.0011 (3.6443)	0.3853 (6.4689)
1981	0.0006 (1.9960)	0.3875 (6.4985)
1982	-0.0004 (-1.3194)	0.2041 (3.2983)
1983	0.0019 (3.6301)	0.4140 (7.0003)
1984	0.0004 (0.6294)	0.2094 (3.3873)
1985	0.0007 (1.8947)	0.3776 (6.3105)
1986	0.0020 (3.6176)	0.2521 (4.1039)
1987	-0.0025 (-2.0134)	0.0155 (0.2516)
1988	-0.0002 (-0.2792)	0.0559 (0.9020)
1989	0.0003 (0.3950)	-0.0365 (-0.5916)
1990	-0.0017 (-2.3342)	0.0924 (1.4897)
1991	0.0008 (1.0761)	0.0755 (1.2141)
1992	0.0001 (0.3256)	0.0942 (1.5292)
1993	0.0012 (1.9237)	0.0717 (1.1556)
1994	-0.0002	0.0295

Table 3 (continued)

Year	α_0	α_1
	(- 0.8039)	(0.4756)
1995	0.0004 (1.0638)	0.1480 (2.3805)
1996	0.0003 (0.8763)	0.0062 (0.1006)
1997	- 0.0001 (- 0.1874)	- 0.2676 (- 4.6226)
1998	0.0003 (- 0.5324)	0.1281 (2.0552)
1999	0.0002 (0.4624)	0.1138 (1.8515)
2000	- 0.0006 (- 1.0147)	- 0.0619 (- 1.0063)
2001	0.0002 (0.5251)	- 0.0129 (- 0.2100)
2002	0.0002 (- 0.6948)	- 0.1245 (- 2.0629)
2003–March 2004	0.0005 (1.6285)	0.0284 (0.5185)

The *t*-statistics are reported in parenthesis.

we can provisionally reject the null hypothesis that the market was efficient and conclude that the New Zealand stock market was inefficient during the first three sub-periods. Clearly, the earlier conclusion about market efficiency does not change. The New Zealand stock market appears to become less inefficient in the more recent decades.

Panel B of Table 2 reports estimation results when we adjust for thin trading and include non-linearity in the model. The coefficients of the lagged and non-linear terms are significant at the 1% level, which implies that the return generating process was both non-linear and dependent on past values during the first two decades. The estimation results during the 1990s show that the linear lagged coefficient is insignificant while the non linear coefficients remain significant. Noticeably, we observe that all of the coefficients including the lagged and non-linear terms are statistically zero during the 2000s, implying that the New Zealand stock market now enjoys enhanced market efficiency. We conclude that when we adjust for thin trading and incorporate non-linearity into our model, we can not reject the null hypothesis of efficiency in the most recent time periods. The New Zealand financial market has become more efficient since the late 1990s.

To investigate the evolution of market efficiency in New Zealand over time, we estimated equations (2) and (3) on annual sub-sets of the index data. The results appear in Table 3. Some of the coefficients of lagged returns are significantly different from zero, but this phenomenon is more prevalent in the early years. We cannot say that the market was efficient for all of the years of the

Table 4 Random walk test on a yearly basis with non-linearities for adjusted NZSE-40 capital index returns

Year	α_0	α_1	α_2	α_3	# of obs.
1970	-0.0003 (-1.1313)	0.3964 (4.7276)	-9.7034 (-1.4320)	-1119.33 (-3.2975)	256
1971	-0.0002 (-0.9004)	0.4568 (5.1342)	1.7098 (0.2488)	-1727.98 (-2.7728)	261
1972	0.0002 (0.8817)	0.6739 (7.7218)	9.6865 (1.1738)	-3347.69 (-3.3675)	260
1973	-0.0012 (-2.9632)	0.4447 (5.6299)	26.2330 (6.6746)	-1213.48 (-6.2395)	261
1974	-0.0010 (-2.0528)	0.4855 (6.1521)	5.1395 (1.3428)	-525.73 (-3.2157)	261
1975	0.0002 (0.5223)	0.4191 (5.3804)	2.7024 (0.4665)	-642.67 (-3.5278)	261
1976	0.0002 (0.6485)	0.4721 (6.2479)	-4.7832 (-0.9417)	-1697.89 (-5.6806)	262
1977	-0.0001 (-0.5800)	0.3932 (4.5233)	-2.9617 (-0.3390)	-1265.06 (-1.4290)	260
1978	0.0002 (0.1115)	0.3709 (4.7778)	17.6487 (1.3350)	-2742.18 (-2.3010)	260
1979	0.0002 (0.8293)	0.3710 (4.8142)	-11.0512 (-1.2308)	-1153.42 (-2.5273)	261
1980	0.0004 (1.5265)	0.4604 (6.1918)	18.5143 (2.6123)	-769.85 (-4.0319)	262
1981	0.0000 (0.1537)	0.4739 (5.6224)	8.5573 (1.4234)	-1234.29 (-2.9229)	261
1982	0.0004 (1.3988)	0.3691 (5.5618)	-38.3699 (-9.1070)	-1105.56 (-9.7226)	261
1983	0.0013 (2.1603)	0.3881 (4.8224)	8.0430 (1.1694)	-309.55 (-1.8381)	260
1984	0.0003 (-0.6017)	0.5915 (7.6319)	2.8200 (1.1757)	-765.29 (-8.7933)	261
1985	0.0005 (1.1126)	0.4510 (5.6534)	1.1034 (0.1941)	-773.96 (-2.8486)	261
1986	0.0011 (1.7612)	0.3373 (3.4968)	5.7470 (1.4497)	-623.47 (-2.7022)	261
1987	-0.0018 (-1.4764)	0.1788 (2.1390)	-3.0366 (-2.3105)	-48.29 (-4.3686)	261
1988	-0.0015 (-1.9727)	0.0647 (0.7724)	8.6303 (3.2723)	-150.14 (-1.7648)	261
1989	-0.0002 (-0.2643)	0.0976 (1.2159)	1.2560 (0.8144)	-92.42 (-3.8098)	260
1990	-0.0015 (-1.8178)	0.0972 (1.0225)	-1.7890 (-0.5652)	-212.63 (-1.5625)	262
1991	0.0006 (0.7287)	0.0827 (0.9476)	0.5453 (0.1482)	-171.15 (-1.5473)	261
1992	-0.0003 (-0.5913)	0.0192 (0.2000)	4.8289 (0.9339)	-137.06 (-0.4034)	262
1993	0.0006 (0.9912)	0.0366 (0.4386)	2.5057 (1.0679)	-48.44 (-0.9360)	261
1994	-0.0011	0.0446	4.9505	-274.66	260

Table 4 (continued)

Year	α_0	α_1	α_2	α_3	# of obs.
1995	(-1.6640) 0.0002 (0.4741)	(0.5161) 0.0388 (0.4326)	(1.3636) -0.5859 (-0.0699)	(-1.7755) 38.67 (0.0798)	260
1996	-0.0002 (-0.5663)	0.0567 (0.6021)	11.6221 (1.7393)	-1033.98 (-2.2646)	262
1997	-0.0006 (-0.9524)	0.0406 (0.4503)	1.5210 (2.4261)	-37.25 (-4.6799)	261
1998	-0.0000 (-0.0565)	0.1359 (1.4193)	-3.8143 (-1.0843)	-255.41 (-1.5445)	261
1999	-0.0005 (-0.7927)	0.1379 (1.4463)	6.5572 (1.5120)	-417.25 (-1.6319)	261
2000	-0.0012 (-1.7267)	-0.1421 (-1.7143)	4.6024 (1.0863)	-4.16 (-0.0308)	260
2001	0.0003 (-0.5194)	-0.0008 (-0.0104)	3.9355 (0.87027)	-133.83 (-1.0660)	261
2002	-0.0008 (-1.9727)	-0.2318 (-2.9586)	13.2190 (1.6329)	350.22 (0.9311)	262
2003–March 2004	0.0005 (1.3029)	0.1498 (1.6196)	-17.9596 (-2.6511)	-1501.15 (-2.2261)	312

The *t*-statistics are reported in parenthesis.

study but, using the linear model, it appears that market efficiency has strengthened in the 1990s and 2000s.

Table 4 shows yearly estimates obtained after applying the non-linear model to correct for thin-trading effects. As in Table 2, incorporating the lagged and non-linearity terms into the adjusted data supports the inference that the later years of the study period are more informationally efficient. Although most of the coefficients of lagged return are significantly different from zero in the early years, we do not find strong statistical evidence of the lagged dependency and non-linearity of the NZSE-40 capital index returns in the years following 1990.

Finally, Tables 5 and 6 report estimation results obtained by maximum likelihood estimation (MLE) when GARCH-M (1, 1) and EGARCH-M (1, 1) models were applied to the thin-trading adjusted returns data. All of estimation results show that there is significant volatility clustering in the New Zealand stock markets evidenced by significant parameter values of β_1 across various sub-periods. In addition, Table 6 reveals strong evidence of leverage effects between the NZSE-40 capital index returns and conditional volatility of the New Zealand stock market. It appears that the New Zealand market has not consistently compensated for its own risks as measured by time-varying volatility. Therefore, it may be difficult to predict stock market returns based on previous volatility because the NZSE-40 capital index returns do not appear to provide investors with a risk premium measured by previous conditional volatility.

Table 5 Parameter estimates of GARCH-M (1, 1) model with non-linearities for adjusted NZSE-40 capital index returns

Period	u_1	u_2	u_3	u_4	δ_1	α_0	α_1	β_1
1970–March 2004	0.0000 (0.3786)	0.2032 (18.8585)	-0.9595 (-1.7293)	-24.6009 (-7.7689)	1.7603 (1.7033)	0.0000 (19.3299)	0.1597 (35.9606)	0.8457 (223.32)
1970–1979	0.0000 (0.5540)	0.4940 (22.5830)	5.5550 (2.7310)	-770.8230 (-8.3490)	-6.0060 (-0.7210)	0.0000 (13.9900)	0.1340 (18.7420)	0.8290 (132.02)
1980–1989	0.0007 (3.8100)	0.3910 (18.8620)	1.3400 (0.8960)	-65.3930 (-5.9590)	-4.1330 (-1.2050)	0.0000 (13.9900)	0.1340 (18.7420)	0.8290 (132.02)
1990–March 2004	0.0003 (1.1431)	0.0586 (2.9442)	2.6223 (1.6278)	-30.3541 (-0.8436)	-4.4371 (-1.1407)	0.0000 (7.3200)	0.1477 (14.9167)	0.8232 (77.68)

The *t*-statistics are reported in parenthesis.

Table 6 Parameter estimates of EGARCH-M (1, 1) model with non-linearities for adjusted NZSE-40 capital index returns

Period	u_1	u_2	u_3	δ_1	α_0	α_1	γ_1	β_1
1970–March 2004	0.0000 (-0.5309)	0.1926 (18.0380)	0.0650 (0.1599)	1.5254 (1.1178)	-0.5606 (-29.7999)	-0.0306 (-8.3258)	0.3007 (51.3056)	0.9645 (570.3966)
1970–1979	0.0000 (3.0960)	0.4000 (21.2330)	2.7320 (1.0850)	-20.1430 (-2.4140)	-3.1720 (-16.1170)	0.4820 (23.2200)	-0.0180 (-1.3230)	0.7360 (41.4910)
1980–1989	0.0000 (3.4410)	0.3540 (19.2270)	3.0580 (2.6870)	-4.5590 (-25.1270)	-4.5590 (-25.1270)	0.6480 (22.2470)	-0.0720 (-3.7830)	0.5710 (31.9310)
1990–March 2004	0.0003 (1.1879)	0.0537 (2.9080)	3.7705 (3.0661)	-6.2770 (-1.7387)	-0.7103 (-11.3875)	-0.0339 (-3.7966)	0.2862 (22.5105)	0.9478 (150.1916)

The *t*-statistics are reported in parenthesis.

V. CONCLUSION

In this paper we examined the market efficiency of the New Zealand stock market considering characteristics such as thin trading and non-linearity, which are prominent in most of emerging markets. As the New Zealand stock market has evolved over time, its institutional and regulatory environments have been enhanced and barriers to entry have been eliminated. The result has been enhanced efficiency and a resultant increase in capital flows.

The New Zealand stock market returns were, to a degree, predictable based on previous returns during the 1970s and 1980s. However, there is no empirical evidence of price dependence and predictability in the New Zealand stock market during more recent decades. The implication is that the New Zealand stock market has become more efficient since 1990 and this improvement can be attributed to regulatory changes and modernization efforts.

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