The Dual-Beta Model: Evidence from the New Zealand Stock Market

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EXTENDED ABSTRACT

Fama and French (1992) show conclusively that the relationship between cross-sectional stock return and beta is flat. Following Fama and French's cross-sectional framework but allowing for up and down market conditions, Pettengill et al.'s (1995) constant-beta model and Howton and Peterson's (1998) dual-beta model both find that beta is significantly positive (negative) in the up (down) markets. Recently, Tang and Shum (2004), using the time-series regression approach with the constant-beta model, find that the beta-return relationship is significantly positive (negative) in the Singapore up (down) markets.

This study extends Tang and Shum's study in examining the dual-beta model in the New Zealand stock market when the market is segmented into up and down markets. Bartholdy and Riding (1994) find that both the Dimson and Scholes and Williams methods previously used on NZ data to correct for beta have no incremental efficiency over the standard OLS estimators. Their study concludes that OLS estimators are most efficient and are closer to those based on synchronous data. We therefore adopt the simple OLS beta estimation in this paper.

Pinfold et al. (2001) argue that the fewer number of NZ stocks and high-volatility of stock prices restrain investors to hold a well-diversified portfolio in the New Zealand stock market. This study thus examines the effect of total risk together with dual betas on stock realized returns.

Consistent with previous studies, our empirical results show that the unconditional beta is flat. While Pinfold et al. (2001) suggest that NZ investors do not hold well-diversified portfolios, we find that total risk does contribute to explaining stock realized returns.

The empirical results of the conditional constant-beta model show that there is a significantly positive (negative) relation between stock realized return and beta in the up (down) markets. However, after we segment the data into up and down market sub-samples (using the dual-beta model), we identify that there exists only a significantly negative relationship between realized return and beta in the down markets; the relationship in the up markets is flat. Although the only significant beta-return relationship in the down markets reveals a special characteristic of the New Zealand stock market, we note that Hodoshima et al. (2000), using the dual-beta model with cross-sectional tests, find that the beta-return relationship in the Japanese market is also significant only in the down markets.

1. INTRODUCTION

The cross-sectional test of Fama and French (1992) provides conclusive evidence of no significant relationship between stock average return and beta.

It is actually premature to conclude that beta is dead. The relationship between stock realized return and beta in the up and down markets has become an important topic in the recent finance literature. Pettengill et al. (1995, hereafter PSM) find a significant positive (negative) relationship between return and beta in the up (down) markets. PSM use the total sample data and a dummy to differentiate up and down markets. We term this as the constant-beta model. Howton and Peterson (1998, hereafter HP), partition the sample data into up (down) markets when the market return is larger (smaller) than the risk-free interest rate. They find a significantly positive (negative) relationship between cross-sectional realized stock return and up-market (down-market) beta. We term HP's model the dual-beta model.

Previous studies on the constant-beta and the dual-beta model all use cross-sectional tests. Tang and Shum (2004) first adopt the time-series regression approach to investigate the constant-beta model in the Singapore market. Their empirical results are consistent with those employing the cross-sectional tests.

This study extends Tang and Shum's time-series framework to the New Zealand stock market when the market is segmented into up and down markets. Our results show that while the constant-beta model brings forth significantly positive (negative) beta-return relationship in the up (down) markets, the dual-beta model only shows that the beta-return relationship is significantly negative in the down markets. The goodness of fit measure, the R-squared, is stronger in the down markets than in the up markets. While our results reveal a special characteristic of the New Zealand stock market, they are actually comparable and consistent to Hodoshima et al.'s (2000) findings in the Japanese stock market.

The rest of this study is organized as follows: Section 2 is a literature review on current empirical studies on the constant-beta and dual-beta models. Section 3 explains the data and methodology used in this study. Section 4 shows our empirical results and Section 5 concludes the study.

2. LITERATURE REVIEW

Empirical studies in the relationship between return and beta can be classified into two major streams: the unconditional beta model and the conditional beta model which segments the whole market into up and down markets. The conditional beta model can further be divided into two models. The first conditional constant-beta model uses a dummy for market conditions in the same regression equation to examine up and down markets.

The second conditional dual-beta model segments the sample data into up and down markets and then examines the up and down market betas separately.

The methodology used in most of the beta models is cross-sectional tests, after Fama and French (1992). Pettengill et al. (1995, 2002) and Howton and Peterson (1998) perform cross-sectional tests with the conditional constant-beta model and the dual-beta model respectively. Recently, Tang and Shum (2004) use the time-series approach to examine the conditional beta issue. They find significant betas in both up and down markets.

2.1. Cross-sectional studies

The Sharpe-Lintner-Black (SLB) model postulates a positive risk-return relationship for individual stocks included in a well-diversified portfolio. However, Fama and French's (1992) cross-sectional tests find virtually no positive relation between stock return and beta. Beta is flat and therefore not useful. Fama and French further suggest that portfolio returns can only be explained by the size and the book-to-market ratio (B/M) of the portfolios. In other words, the unconditional SLB model is not useful to explain cross-sectional stock returns.

When the market is considered for up and down markets, Pettengill et al. (1995) find that there exists a significantly positive (negative) relationship between cross-sectional stock realized return and beta in the up (down) markets. Supportive evidence of significant conditional relationship between stock return and beta is also found in the Swiss stock market over the period 1973 to 1991 (Isakov 1999).

Wiggins (1992) argue that the dual-beta model where the sample data is segmented into either the up or the down market sample set in fact gives a stronger explanation for monthly cross-sectional returns. However, both Pettengill et al. (1995) and Isakov (1999) use a dummy variable to identify up and down markets in a single cross-sectional regression equation. Howton and Peterson (1998) find empirically that after the sample data is segmented into up and down markets, there is a significantly positive (negative) relationship between cross-sectional stock return and up market (down market) beta. The advantage of the dual-beta model, according to Hodoshima et al. (2000), is that it allows the intercept to vary according to up and down market conditions. They also find similar and consistent significantly positive (negative) return-beta relationships in the up (down) market sub-period data. The dual-beta model is thus more flexible and natural in testing the relationship between cross-sectional stock returns and conditional betas.

2.2. Time-series studies

While the cross-sectional model assigns the portfolio beta to each individual firm (Fama and French 1992, HP 1998, and Pettengill et al. 2002), a time-series regression model matches the returns of each portfolio with their corresponding portfolio betas. Moreover, in the cross-sectional model an average beta value has to be calculated for obtaining the t-statistic measures. A time-series regression simply runs a stacked regression of the returns against betas to identify the relationship.

Tang and Shum (2004) first use time-series regressions to examine the conditional relationship between stock return and beta in the Singapore market. They run a stacked regression between monthly realized excess return of the portfolio and the matched portfolio beta. Without segmenting the sample data into up and down market sub-samples, a dummy variable is used in their regression to distinguish the up and down market conditions. Their empirical results successfully identify a significantly positive (negative) relationship between stock return and beta in the up (down) Singapore market. More importantly, using the time-series OLS regression model, the significant conditional relationships between stock return and beta in the up and down markets do not disappear even after additional statistical measures such as skewness and kurtosis, etc., are added into the model.

Tang and Shum (2004), however, do not examine the dual-beta model in their study. This study first uses New Zealand data to investigate the dual-beta model with the time-series regression approach.

3. DATA AND METHODOLOGY

This section first introduces the data source. The New Zealand stock market has a serious thin trading problem which impacts beta estimation. We adopt Bartholdy and Riding's (1994) recommendation to deal with the thin trading problem. We then specify the unconditional beta, conditional constant-beta, and conditional dual-beta models. Pinfold et al. (2001) point out that the New Zealand stock market is not well-diversified. As a result, stock realized returns can be explained by the total risk. The total risk variable is thus considered in each of our beta models.

3.1. Data

We collect New Zealand (NZ) monthly stock prices, the number of shares outstanding, three market indices, and the risk-free interest rate from Datastream. The whole sample period spans March 1991 through December 2003. This period covers 154 months and the initial sample set contains 184 NZ firms. The trading frequency of a firm is required to be more than 90% of the time over the sample period. After data screening, the final sample set reduces to 82 firms with an aggregate market value of 80% of the total stock market capitalization, as at 1 December 2003. Roll (1977) critiques that the CAPM completely depends on the chosen market index. We collect three NZ market indices (NZSE40, NZSE All, and Total Market) but find them to be highly correlated. Therefore, only the NZSE40 index is adopted in this study. The one-month NZ interbank offer rate is used in this study as the risk-free interest rate to segment market conditions into up and down markets. In this study, 52% of the monthly market excess returns are negative.

When a stock is traded less frequently than the market index, the beta estimates can be biased downward (Bartholdy and Riding 1994). The aggregated coefficient method of Dimson (1979) is used in Blume and Stambaugh's (1983) study to adjust for the infrequent trading effect. Berglund, Liljeblom and Löflund (1989) use a generalization of Scholes and Williams's (1977) estimator to deal with non-synchronous stock price adjustments and infrequent trading in individual stocks on Finland data. Bartholdy and Riding (1994) use both the Dimson and Scholes and Williams methods on NZ data to correct for beta biases. They however find that the two beta-correcting methods have no incremental efficiency over the standard OLS estimators and conclude that OLS estimators are most efficient and are closer to those based on synchronous data. We therefore adopt the simple OLS beta estimation in this study.

3.2. Tang and Shum's (2004) portfolio formation procedure

Tang and Shum's (2004) portfolio formation procedure is followed in this study to estimate the conditional betas. The full sample period is divided into three consecutive none-overlapping sub-periods: the portfolio construction period (April 1991 – March 1994), the parameter estimation period (April 1994 – March 1997), and the model testing period (April 1997 – December 2003).

Stock excess returns in the portfolio construction period are regressed against market excess returns in the prior 36 months in order to obtain firm betas. All of the 82 NZ firms are sorted in ascending order according to their beta values. The firms are then evenly distributed into 10 portfolios: the first portfolio contains the firm with the smallest beta value and the last portfolio contains the firm with the largest beta value.

Pinfold et al. (2001) point out that the fewer number of NZ stocks and high-volatility of stock prices restrain investors to hold a well-diversified portfolio in the New Zealand stock market. This study thus investigates the effect of total risk together with dual betas on stock realized returns. Therefore, in the parameter testing period (April 1994 – March 1997), both beta and total risk are estimated for each of the ten portfolios. In the model testing period, the equally-weighted excess returns of the ten portfolios in the first month (April 1997) are matched with their corresponding beta and total risk that are estimated in the previous sub-period. The overall process are then repeated in loop by deleting the first month's return (April 1991) of the portfolio forming period and adding the second month's return (May 1997) of the testing period. The first month's portfolio return of the testing period is moved into the parameter calculation period for obtaining the corresponding total risk as the parameter period has to be maintained for 3 years. We continue this process until the last month (December 2003) of the testing period is finally reached. The risk-free interest rate is used in the process to determine whether the market generates a positive or negative excess return in each month of the testing period. The monthly observations of the ten portfolios are further segmented into up and down sub-samples.

In the constant-beta model, we run a stacked regression of all the portfolio observations in the model testing period together. In the dual-beta model, we obtain the up and down sub-samples before running the stacked regressions.

3.3. OLS regression models

The unconditional and conditional relationships between stock realized return and constant beta or dual betas are examined with and without the presence of the total risk by using the following regressions:

Unconditional beta model:

$$R_{jt} = \gamma_0 + \gamma_1\beta_{jt} + \gamma_2\sigma^2_{jt} + \eta_{jt} \quad (1)$$

where R_{jt} denotes portfolio excess return, β_{jt} and σ^2_{jt} denote the beta and the total risk of portfolio j at time t, respectively.

Conditional constant-beta model:

$$R_{jt} = \gamma_0 + \gamma_1\lambda\beta_{jt} + \gamma_2(1-\lambda)\beta_{jt} + \gamma_3\lambda\sigma^2_{jt} + \gamma_4(1-\lambda)\sigma^2_{jt} + \eta_{jt} \quad (2)$$

where $\lambda = 1$ if $(R_{mt} - R_{ft}) > 0$ and $\lambda = 0$ if $(R_{mt} - R_{ft}) < 0$, where R_{mt} is the return of NZSE40 index and R_{ft} is the one-month NZ interbank offer rate in month t, respectively. We also perform the constant-beta model for the sub-periods to test the robustness of the conditional relationship between stock return and the constant beta.

The overall observations are then partitioned into two sub-samples according to whether the monthly market excess return is positive (up market) or negative (down market) to test for conditional dual betas.

Conditional dual-beta model:

$$R^m_{jt} = \gamma_0 + \gamma_1\beta^m_{jt} + \gamma_2\sigma^2_{jt} + \eta_{jt} \quad (3)$$

where m = u (up market) or d (down market). Note that the conditional dual-beta model is the same as the unconditional beta model in terms of the equation format while the conditional dual-beta equation (3) is employed in segmented up and down market samples respectively. Note that the intercepts are allowed to be distinguished for the two market conditions in the dual-beta model.

4. EMPIRICAL RESULTS

This section reports the empirical results of the unconditional beta model and the dual-beta model. We find that there is a special characteristic of the New Zealand stock market: beta and return are significantly negatively related in the down markets and the relationship is flat in the up markets.

4.1. Unconditional beta model

The SLB model postulates a statistically significantly positive beta coefficient. In this study, we find that the unconditional beta coefficient is negative but not significant (Table 1). Therefore, beta is flat, a result consistent with Fama and French (1992). When total risk is added in the unconditional beta model, the beta coefficient is significantly negative. This means that investors are receiving less returns when they bear more systematic risk. However, this is not reasonable. On the other hand, the total risk variable is significantly positive. This implies that NZ investors do not hold well-diversified portfolios. Investors are compensated for bearing total risk.

Table 1.
Results of unconditional beta model without and with total risk

810 observations from April 1997 to December 2003				
Additional Variable	γ_0	γ_1	γ_2	Adj. R^2
None	0.0032 (0.62)	-0.0103 (-1.57)		0.0018
Total Risk	0.0056 (1.09)	-0.0272 (-2.71***)	3.0628 (2.20**)	0.0080

t-statistics in parentheses
***Statistically significant at the 1% level
**Statistically significant at the 5% level

4.2. Conditional constant-beta model

Once the market is separated into up and down markets, the empirical results of the conditional constant-beta model indicate that there is a significantly positive (negative) relationship between stock return and beta in the up (down) markets. Table 2 reports that both of the up and down constant betas are statistically significant at the 1% level. Portfolios with high systematic risk generate higher returns in the up markets and they also bear larger losses in the down markets.

When total risk is added in the model, the up (down) constant betas remain significantly positive (negative) in the up (down) markets. However, total risk is only significantly positive in the down markets but is flat in the up markets. This implies that investors holding undiversified portfolios are compensated for bearing additional total risk in the down markets. In the up markets, undiversified portfolios are solely rewarded by bearing systematic risk.

Wald tests show that in equation (2), γ_1 is significantly different from γ_2 and γ_3 is significantly different from γ_4. Equation (2) is therefore well-specified to examine the up and down market betas. The conditional constant-beta model would not collapse to the unconditional beta model. [1]

4.3. Sub-period results of the conditional constant-beta model

Sub-period tests are first performed in Tang and Shum (2004). The authors find that conditional betas remain significant in sub-periods and thereby argue that the results from the conditional constant-beta model are robust.

In this study, there are six sub-periods where the first five sub-periods have a span of 12 months and the last one has 21 months. Results are not shown in this paper to save space. Betas in the up markets are all flat except the earliest sub-period (April 1997 - March 1998). On the other hand, betas in the down markets are significantly negative in all sub-periods.

When total risk is added in the model, total risk is found to be completely flat in the up markets in each of the sub-periods. While total risk is significantly positive in the full sample period (Table 2), it is only significantly positive in the second sub-period (April 1998 - March 1999). This reflects that investors are only compensated for holding undiversified portfolios in the long run.

[1] Empirical results are not shown due to the space limitation.

Table 2. Results of conditional constant-beta model without and with total risk

810 observations from April 1997 to December 2003						
Additional Variable	γ_0	γ_1	γ_2	γ_3	γ_4	Adj. R^2
None	0.0016 (0.33)	0.0232 (3.48***)	-0.0366 (-5.58***)			0.1837
Total Risk	0.0037 (0.78)	0.0267 (2.59***)	-0.0717 (-6.28***)	-1.2385 (-0.80)	7.0381 (3.53***)	0.2034

t-statistics in parentheses ***Statistically significant at the 1% level

Table 3. Results of conditional dual-beta model

810 observations from April 1997 to December 2003; 390 observations for the up markets and 420 for the down markets					
Additional Variable	γ_0	γ_1	γ_2	Adj. R^2	AIC
Up markets:					
None	0.0190 (3.11***)	0.0045 (0.54)		-0.0018	-2.96
Total Risk	0.0190 (2.93***)	0.0080 (0.67)	-0.6303 (-0.41)	-0.0040	-2.96
Down markets:					
None	-0.0169 (-2.50**)	-0.0175 (-2.02**)		0.0080	-2.91
Total Risk	-0.0118 (-1.75*)	-0.0533 (-4.13***)	6.5357 (3.28***)	0.0472	-2.95

t-statistics in parentheses
***Statistically significant at the 1% level
** Statistically significant at the 5% level
* Statistically significant at the 10% level

4.4. Conditional dual-beta model

In the conditional constant-beta model (Equation 2), the constant γ_0 is not significantly different from zero (Table 2) with or without the presence of total risk. In the conditional dual-beta model (Equation 3), the constant γ_0 is significantly positive (negative) in up (down) markets with or without the presence of total risk (Table 3). This means that when there is no systematic and/or unsystematic risk the average excess return is significantly positive (negative) in the up (down) markets. Thus, the conditional dual-beta model has successfully differentiated the up markets from the down markets. In the full sample period, the positive average excess returns in the up markets offset negative average excess returns in the down markets resulting in a flat average excess return.

In the up markets, beta is flat with or without total risk. On the other hand, beta is significantly negative in the down markets, with or without total risk (Table 3). Our empirical results have revealed a special market characteristic of the New Zealand stock market: the conditional dual-beta model with time-series tests works better in down markets.

Hodoshima et al. (2000) use cross-sectional tests to test the conditional dual-beta model with Japanese data. They conclude that "the conditional relationship between return and beta is found to be in general better fit when the market excess return is negative than positive in terms of the goodness of fit measures such as R2 and the standard error of the equation (p.515)." In Hodoshima et al. (2000), about 40% of monthly market excess returns are negative. In our study, about 52% of monthly market excess returns are negative. Although the stock market, sample period, and methodology adopted in this study are different from Hodoshima et al.'s, the results of this study are consistent and comparable to Hodoshima et al.'s study.

5. CONCLUDING REMARKS

In this study, we first use New Zealand stock market time–series data to examine both the unconditional beta, the conditional betas with the full sample data, and the dual betas when the sample is segmented into up and down markets.

Consistent with previous studies, we find that the unconditional beta is flat. According to Pinfold et al. (2001), NZ investors do not hold well-diversified portfolios. We find that the total risk contributes to explaining stock realized returns.

The empirical results of the conditional constant-beta model show that there is a significantly positive (negative) relation between stock realized return and beta in the up (down) markets. However, when the data is segmented into up and down market sub-samples (using the dual-beta model), we identify that there is a significantly negative relationship between realized return and beta in the down markets; however, the relationship in the up markets is flat. Although our results reveal a special characteristic of the New Zealand stock market, we note that Hodoshima et al. (2000) also find that, using the dual-beta model with cross-sectional tests, the beta-return relationship is only significant in the down markets in the Japanese stock market.

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