Risk Measurement and Size Effect on the Dutch Stock Market

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ABSTRACT

In this paper the relationship between size effect and the bias in the measurement of the systematic risk on the Dutch stock market is investigated. Firstly, it is found that there is an intervalling effect in the beta coefficients. The sign of the intervalling effect coefficient is generally negative, implying that betas measured on short differencing intervals underestimate their asymptotic values. To investigate the relationship between the intervalling effect bias and the size effect, the models proposed by CHMSW and Handa, Khotari and Whasley were employed. The former model puts in evidence a significant relationship between the two effects, while the latter does not.

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1 Introduction

A considerable body of research in finance has been concerned for some years with the existence of market anomalies in security markets. The anomalous empirical regularities can be classified into cross-sectional empirical regularities or seasonal regularities. The anomalous cross-sectional regularities, or anomalies related to some firm or market attributes, are systematic and persistent deviations from the equity pricing models such as the Capital Asset Pricing Model (CAPM). An example of cross-sectional empirical regularity is the Size Effect (Banz, 1981) according to which firms with a relatively lower market value of equity seem to achieve returns above those warranted by the CAPM. The existence of such market anomaly can be interpreted as a misspecification of the CAPM. That means there may exist a risk factor in addition to systematic risk which is relevant in the pricing of securities, or at least a factor influencing the pricing. As to the seasonal empirical regularities which can be considered as violations of the efficient market hypothesis, the most common are the January Effect (Rozeff and Kinney, 1976 and Gultekin and Gultekin, 1983), that is average monthly returns are larger in January relatively to the rest of the year, the Weekend or Monday Effect (French, 1980, Gibbons and Hess, 1981 and Lakonishok and Levi, 1982), that is, average return on Monday is significantly less than the average return over the other days of the week, and the Turn-of-month (Ariel, 1987 and Lakonishok and Smidt, 1988), that is, returns at the turn of the month are significantly higher than those of the rest of the year.

Both types of anomalies have been observed in almost all security markets. Despite efforts and time devoted to their study, they remain a puzzle insofar as suggested explanations are not unanimous and do not explain, at least not completely, their existence.

We are concerned in this paper with the first type of anomalies, more specifically with the size effect and its relationship with the bias in the measurement of the systematic risk due to the choice of the length of the differencing interval used to calculated the returns. The latter, which is commonly called the intervalling effect, can be due to nonsynchronous trading or, more generally, to delays in the price adjustment which can be caused by the microstructure of the market and the reaction of investors to the arrival of news. The first models dealing with this intervalling effect bias in beta were presented by Scholes and Williams (1977) and Dimson (1979). Both imputed the intervalling effect bias in beta to infrequent trading. Their models consist in regressing observed returns against synchronous or lagged market returns in order to avoid the problem of serial correlation, and then in aggregating the slope coefficients obtained to calculate a beta estimate. Cohen, Hawawini, Maier, Schwartz and Whitcomb, henceforth CHMSW, (1980), developed a more general model for correcting the empirical estimates of beta for the intervalling effect due to any type of delays in the price adjustment. According to their theory the expected magnitude of the price adjustment delays is related to the thinness of the securities: thinner securities have greater adjustment delays than frequently and highly traded securities. They also demonstrated that thin securities have a downward bias in their betas for short differencing intervals, while relatively frequently traded securities have an upward bias.

As the market value of a firm is generally used as a proxy variable for the thinness of a security, the relationship between intervalling effect bias in beta and thinness would suggest that the intervalling effect could explain the size or small firm effect. Roll (1981) argued that trading infrequency, which induces some autocorrelation in the market indexes, seems to be a powerful cause of bias in the systematic risk estimation and could explain the small firm effect. And, according to CHMSW, the adjustment for the intervalling effect bias should be more important for small firms than for large firms. More recently, results of Handa, Kothari and Wasley (1989) study on US data found no statistically significant relationship between firm size and systematic risk when risk is measured by betas estimated using long differencing intervals. While Martikainen and Pertunen (1991) showed a positive relationship between firm size and betas for the Finnish stock market.

The rest of the paper is organised as follows. Section 2 presents the data and section 3 discusses CHMSW procedure to obtain an asymptotic beta. Section 4 deals with the relationship between systematic risk for different interval length and the size effect. Section 5 concludes and presents a brief summary.

2 Data

Our sample consists of 50 Dutch firms. The daily closing prices for a period starting 28/10/87 and ending 1/3/92 are used to calculate the returns. Returns for any interval length are calculated as the difference between the natural logarithm of two closing prices, $R_t=\ln(P_t+D_t)-\ln(P_{t-1})$, where D_t denotes the dividend. The CBS general index, the most appropriate index available in the Netherlands, is used as a proxy of the market index. It is a weighted average of a number sector indices and is adjusted for dividends. As for the market value of the firms, it is that of 31 December 1990. This date which is the midpoint of our sample period was chosen such that the market value of the outstanding shares are close to their actual average over this period.

3 Measurement of Systematic Risk

We assume that the security returns are generated by the Market Model of Sharpe (1963),

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \quad t=1,....,T \tag{1}$$

where β_i, the security beta, measures the change in R_{it} as a result of a change in the market index return R_{mt}, α_i measures the change in R_{it} that is independent of a change in R_{mt}, and ε_{it} is the random error term. According to this model, β_i should not depend on the length of the differencing interval used to calculate the returns. However, empirical studies showed that there is an impact of the length of the differencing interval used to measure the returns on the estimated betas. Examples can be found in, among others, Berglund, Liljeblom, and Löflund (1989) for Finland, Corhay (1992) for Belgium and Corhay and Tourani Rad (1992) for the Netherlands.

CHMSW (1983) presented two procedures for correcting the empirical estimates of beta for the intervalling effect. Their first procedure consists in estimating an asymptotic beta by increasing the length of the differencing interval, and the second one consists in adjusting the beta estimates by cross-sectional differences in the intervalling effect. A proxy variable for the security thinness, for example, the market value of the outstanding shares, is used to determine the cross-sectional differences. These procedures were tested by CHMSW (1983), by Fung, Schwartz and Whitcomb (1985) and by Corhay (1988) on samples of 50 American, 52 French and 250 Belgian securities respectively. The results of these three studies support CHMSW's theory while another study of McInish and Wood (1986), using intermediate results of CHMSW, does not.

We calculate the asymptotic betas for the firms in our sample. But, since the size of the sample cannot be increased without bounds and β_i is not necessarily stationary across time, we follow Cohen et al. (1983) second procedure to obtain asymptotic betas. This requires two steps. First the security beta coefficients are estimated for a finite set of length of the differencing interval. These betas estimated using equations (1) are then used in a second pass regression to calculate estimates of the security asymptotic beta, as well as a measures of the intervalling effect:

$$\hat{\beta}_{iL} = \hat{\beta}_i + \hat{\gamma}_i f(L^{-n}) + \upsilon_{iL} \qquad (2)$$

where $\hat{\beta}_i$ is the estimator of the asymptotic beta coefficient, $\hat{\gamma}_i$ is a measure of the intervalling effect on the beta of security i and L is the length of the differencing interval. As CHMSW noted, functional forms which converge to an asymptote, the value of the asymptotic beta, and for which the difference between the dependent variable and the asymptote decreases with L, could be used in (2). Any inverse function of L satisfies these requirements. Furthermore, in order to use only linear regressions, they suggested to use powers of the inverse functions of L, the value of the power being determined experimentally. In their study on the U.S. data, CHMSW simply used the inverse of the length of the differencing interval L^{-n}, while Fung, Schwartz and Whitcomb (1985) found the function $\ln(1+L^{-n})$ fitted the French data best. We tested various inverse functions of L for the Dutch market, that is, L^{-n}, $\ln(1+L^{-n})$, $\ln(1+L)^{-n}$ and $\exp(-L^{-n})$, and it appeared that the function $L^{-.8}$ fits the data best. Estimated asymptotic betas and intervalling effect coefficients for the 50 firms are reported in table 1. It can be noticed that the sign of the intervalling effect coefficient is generally negative, which means that observed betas for small differencing intervals underestimate their asymptotic values. The firms with large market values, which tend to be thicker than our index have, however, a positive intervalling effect coefficient, which is consistent with CHMSW theoretical model and the empirical findings on US and other equity markets.

4 Intervalling Effect and Firm Size Effect

In order to test the relationship between the intervalling effect and the size effect, two models are used. The first one, proposed by CHMSW (1983) is a cross-sectional regression with the natural logarithm of the market value (MV) of the firms as independent variable and the betas $\hat{\beta}_{iL}$, measured using various differencing interval length, and the asymptotic beta estimate $\hat{\beta}_i$ as dependent variables (ψ). That is:

$$\psi = \psi_0 + \psi_1 \, MV \tag{3}$$

Results of this model for betas calculated using intervals of 1 to 5, 10, 15, 20 days and for the asymptotic one are reported in table 2. The slope coefficients of the betas are all positive and statistically significant. The R^2 of the regressions are also quite high. This indicates clearly that betas are related to the market value. The examination of the behaviour of the slope coefficient with regards to the length of the interval is interesting. One should expect that if the firm size effect is explained by the intervalling effect, the slope coefficient should decrease and become insignificant for long intervals. This pattern can be observed in the results, the value of the coefficient decreases when the differencing interval is lengthened, and is the lowest when the asymptotic beta estimate is the dependent variable. All coefficient are, however, statistically significant, which means that after being adjusted for the intervalling effect bias, betas still depend on the market value. The adjustment for the intervalling effect bias in the Dutch firm betas only decreases the magnitude of the size effect. This impact on the size effect is less conclusive than for the American sample. In their study, CHMSW found a significant impact of the adjustment on the relationship between the beta and the size of the firms.

The second model for testing the relationship between the intervalling effect and the size effect consists in running another cross-sectional regressions, where the returns of the firms are assumed to be a function of betas and market values, are run for each interval length:

$$R_{iLt} = \hat{\gamma}_{0iL} + \hat{\gamma}_{1iL} \hat{\beta}_i + \hat{\gamma}_{2iL} \, MV + \varepsilon_{iL} \tag{4}$$

Following Handa, Kothari and Wasley (1989), we assume there is an estimation error υ in the estimated betas with zero mean, constant variance and no cross-sectional correlation. Then plim for g_2, which is an estimate of γ_2, is :

$$\text{plim } g_2 = \gamma_2 + \frac{\text{var}(\upsilon)\text{cov}(\hat{\beta}_i, MV_i)}{\text{var}(MV_i)\left(\text{var}(\hat{\beta}_i) + \text{var}(\upsilon)\right) - \text{cov}(\hat{\beta}_i, MV_i)} \gamma_1 \tag{5}$$

In the absence of any theoretical relationship between firm size and expected returns, γ_2 should be zero. Most empirical studies suggest there is a negative relationship between firm size and beta. In this case, $\text{cov}(\hat{\beta}_i, MV_i)$ is negative and the denominator is positive. Thus bias in g_2 increases with $\text{var}(\upsilon)$, but it can be negative and statistically significant when beta is measured with error. Handa et al. showed the error in betas using long differencing intervals is lower than using short intervals. Their results show that the size effect decreases with the length of the differencing interval and become insignificant for yearly intervals. An positive relationship between beta and firm size has, however, been reported by Martikainen and Perttunen (1991) for the Finnish market. They observed, indeed, that the firm size effect increases with the length of the differencing interval for this thin market. As for the Dutch market, we apply this model for L = 1 to 5, 10, 15, and 20 days. It can be observed that none of the coefficients of the market value in model (4), as reported in table 3, is on average statistically significant, which means that the hypothesis of no relationship between the returns and the size of the firms cannot be rejected. In other words, based on this model we do not obtain conclusive results regarding the relationship between firm size and the intervalling effect.

5 Conclusions

The objective of this paper was to investigate the relationship between size effect and the bias in the measurement of the systematic risk on the Dutch stock market. We found first that there is an intervalling effect in the beta coefficients. The sign of the intervalling effect coefficient is generally negative, implying that betas measured on short differencing intervals underestimate their asymptotic values. To investigate the relationship between the intervalling effect bias and the size effect, the models proposed by CHMSW and Handa, Khotari and Whasley were employed. The first model puts in evidence a significant relationship between the two effects, while the second model does not. Results of the first model further show that the magnitude of the size effect is reduced when the interval length is increased, but remains statistically significant.

6 References

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Table 1 : Asymptotic betas and intervalling effect coefficients

Firm	Asymptotic betas $\hat{\beta}_{iL}$	Intervalling effect $\hat{\gamma}_i$
1	0.7121	-0.3670
2	1.0049	0.1759
3	1.0817	0.1389
4	1.1813	0.0889
5	1.1237	0.3357
6	1.4197	0.3160
7	1.6381	1.3379
8	0.8863	0.5365
9	0.8760	0.2779
10	0.7143	0.6711
11	1.1283	1.2061
12	1.5015	0.4008
13	0.5145	0.0130
14	1.0768	0.3512
15	0.9126	0.6458
16	0.9696	0.6218
17	1.4115	0.0469
18	0.6914	0.6377
19	1.1160	0.2392
20	1.4600	-0.0740
21	1.8489	-1.0329
22	1.3647	-0.8314
23	0.8519	-0.3312
24	0.7855	-0.4859
25	0.5591	-0.4627
26	0.9622	-0.3694
27	0.6532	-0.1695
28	0.7461	0.0560
29	0.6124	0.4050
30	0.8716	-0.6373
31	0.4923	-0.4256
32	1.4627	-0.2008
33	0.1973	-0.0934
34	-0.0028	0.0643
35	1.0222	-0.6976
36	1.2831	-0.9004
37	0.2522	-0.1586
38	1.1573	-1.3009
39	0.9903	-0.5024
40	-0.1573	0.2977
41	0.9822	-0.3778
42	0.9581	-0.2889
43	0.5885	-0.6407
44	1.0633	-0.3641
45	1.1456	0.2051
46	0.7790	-0.6130
47	1.3546	-0.8301
48	1.1801	-0.2316
49	1.6952	-1.1926
50	0.6226	-0.1684
Mean	0.9548	-0.3915

Table 3 : Intervalling Effect and Firm Size

$$R_{iLt} = \hat{\gamma}_{0iL} + \hat{\gamma}_{1iL}\,\hat{\beta}_i + \hat{\gamma}_{2iL}\,MV + \varepsilon_{iL}$$

Interval length	γ_0	$t(\gamma_0)$	γ_1	$t(\gamma_1)$	γ_2	$t(\gamma_2)$	R^2	F-test
1	-0.00234	-0.1462	-0.00145	-0.1843	0.00034	0.1743	0.0827	2.3513
2	-0.00404	-0.1871	-0.00269	-0.2311	0.00061	0.2278	0.0799	2.2543
3	-0.00469	-0.1589	-0.00310	-0.1901	0.00075	0.2042	0.0726	1.9595
4	-0.00482	-0.1628	-0.00314	-0.1875	0.00084	0.2168	0.0711	1.9608
5	-0.00405	-0.1483	-0.00283	-0.1661	0.00082	0.2016	0.0703	1.9015
10	0.00080	-0.0724	0.00012	-0.1099	0.00047	0.1336	0.0801	2.1709
15	0.00153	-0.0957	0.00346	0.0144	0.00045	0.1533	0.0844	2.3250
20	0.00238	-0.0587	0.00429	0.0389	0.00058	0.1356	0.0911	2.6238

Table 2: Intervalling Effect and Firm Size *

$$\psi = \psi_0 + \psi_1 \, MV$$

Interval	ψ_0	ψ_1	R^2
1	-1.6400	.1997	.6345
2	-1.4099	.1820	.5977
3	-1.3139	.1744	.5806
4	-1.1933	.1662	.5563
5	-1.1184	.1611	.5427
10	-1.0749	.1650	.4751
15	-0.8699	.1554	.3798
20	-0.7525	.1515	.3184
Asymptotic	-0.8099	.1506	.3738

* All coefficients are significant at the one percent level.