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THE IMPACT OF INFREQUENT TRADING ON BETAS BASED ON DAILY, WEEKLY AND MONTHLY RETURN INTERVALS: Empirical Evidence with Finnish Data*

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This paper examines the empirical properties of common stock systematic risk estimates measured from daily, weekly and monthly return intervals in the Finnish stock market. Firstly, the effects of infrequent trading on betas measured from the three return intervals are analysed. Secondly, it is aimed to find out whether the differences in the stability of the selected systematic risk estimates can be explained by infrequent trading. Thirdly, the linear risk-return relationship suggested by the CAPM is tested using the different systematic risk estimates. In addition, two widely discussed anomalies, the size-effect and the E/P-effect, are focused in this context.

1. *Introduction*

A substantial part of literature in finance has been devoted to the estimation of systematic risk, i.e. beta. This is due to the fact that in the most famous equilibrium model of finance, i.e. in the Capital Asset Pricing Model (CAPM), the expected return and systematic risk of a security are assumed to be linearly related to each other. Traditionally, betas have been estimated using the market model by Sharpe (1964).[1] Unfortunately, the estimation of betas contains several statistical problems.[2] For instance, with the intervalling effect, one is usually referring to the problems caused by measuring returns from different intervals. Estimated betas from longer return intervals, such as monthly betas, typically have higher values than daily betas. In Hawawini (1983) it was shown that the sensitivity of estimated betas to the return interval is primarily due to autocorrelated market indices as well as intertemporal cross-correlations between the market return and those of individual securities. He reported the major implication of the intervalling effect as the nonsynchronous bias when daily betas are estimated. The effects of nonsyncronous bias are due to the fact that, because of thin trading, returns are not measured from identical time intervals. The measured variances overstate the »true» unobservable variances and understate the »true» covariances. Thus, the estimated betas of infrequently traded stocks are biased downward.

Several methods have been proposed to correct for the problems caused by nonsyncronous trading. Recently, Berglund, Liljeblom and Löflund, henceforth BLL, (1989) tested the most famous of these methods using

* *The useful comments of two anonymous referees for this journal are gratefully acknowledged.*

[1] *See section 2.*

[3] *See e.g. Huang and Litzenberger (1988), and Copeland and Weston (1988) for a review.*

daily Finnish data.[3] They concluded that these different procedures to estimate systematic risk did not perform much better than the traditional market model. All of the beta estimates were found to be significantly biased by infrequent trading. In addition, they found that the ranking of betas conveyed statistically significant information about the ranking of the betas in the consequent period when betas based on daily return intervals were used. However, a substantial part of the observed stability was reported to consist of cross-sectional differences in trading frequency and firm size. The use of a priori preferable methods, such as trade-to-trade returns, seems to eliminate only relatively few of the problems caused by nonsyncronous price behaviour in the Finnish stock market, due to the Finnish trading mechanisms (Berglund and Liljeblom 1988).[4]

This paper extends the study by BLL (1989) in three levels. While in their study only daily data was used, this study uses daily, weekly as well as monthly return intervals. This article also considers the cross-sectional association between the different beta estimates and expected stock returns. Assuming the differences between beta estimates were entirely due to larger standard errors of the betas based on longer return intervals, these betas should be less related to return variation. On the other hand, if the betas based on shorter return intervals are significantly biased by infrequent trading, their ability to explain return variation should be low. Thus, the optimal return interval is very much an empirical question in this context. Finally, it is investigated whether the well-known size- and E/P-anomalies loose their explanatory power when beta estimates less biased by infrequent trading are introduced.

The remainder of this article is organised as follows. First, in section 2 the data is described. The empirical analysis of this study is carried out in three phases in the third section. First, in section 3.1. the stability of betas measured from monthly, weekly and daily return intervals is analysed. Then, in section 3.2. the effects of infrequent trading on these betas and their stability over time are studied. In section 3.3. the effects of trading frequency on the empirical risk-return relationship suggested by the CAPM are investigated. In addition, the E/P- and size-anomalies are focused in this context. Finally, in section 4 conclusions are drawn.

2. Data description

In empirical research in the realm of finance, the selection of the data base is a crucial aspect. In order to study the differences in betas measured from alternative return intervals, monthly, weekly and daily returns are collected from the Helsinki Stock Exchange. Returns are determined as changes in logarithmic indices including dividends, issues and splits, i.e.

$$(2) \qquad r_{it} = \log_e(P_{it}) - \log_e(P_{it-1}),$$

where

r_{it} = return in stock i in period t

P_{it} = stock price index in the end of period t for firm i

The changes in logarithmic price indices can be regarded as good approximations of returns, assuming continuous compounding. For a day with no trade, the true price is proxied by the bid quotation. When several trading prices for the same stock on the same day have occurred, arithmetic averages for these prices have been computed. Weekly returns are calculated by Wednesday returns. Monthly returns are calculated using differences of the closing values of the price indices for each month. The returns are collected from the period of January 1971 to December 1986.

The beta coefficients have been calculated

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[3] The traditional market model betas, the betas proposed by Cohen, Hawawini, Maier, Schwartz and Whitcomb (1983 a), and the GLS trade-to-trade betas were compared. In addition, the betas by Vasicek (1973) were computed since it was assumed that the Bayesian adjustment applied in these betas would reduce some of the thin-trading related problems.

[4] A specific institutional factor leading to a high level of serial correlation in returns and relatively poor results concerning trade-to-trade returns may be the trading mechanism in the Helsinki Stock Exchange during the research period. Trading in each stock started with »calling out» where only a part of the trades for the day were executed, while the rest of the trades occurred in the »aftermarket», where the trading prices were limited by the highest bid and the lowest ask at the end of the »calling out» (see e.g. Berglund and Liljeblom 1988, 1990).

using Sharpe's market model, i.e. from the following regression equation:[5]

(3) $r_{it} = \alpha_i + \beta_i r_{mt} + \varepsilon_{it}$, where

r_{it} = return of stock i in period t
α_i = estimated intercept term for stock i
β_i = estimated beta coefficient of stock i
r_{mt} = return of the market portfolio in period t
ε_{it} = estimated unsystematic return component of stock i in period t

The market index used in this study is introduced by Berglund, Wahlroos and Grandell (1983). This market index is preferable theoretically, compared with the other main indices used in Finland, because of its value-weighted approach. In the index, the prices are corrected for dividends, splits and new issues. The dividends are assumed to be reinvested with zero transaction cost.

In addition to return data, information concerning the market capitalisation and earnings has been collected to study the so-called E/P- and size-effects on Finnish data.[6] The market capitalisation figures have been determined using the closing prices of stocks for each year.

3. *Empirical results*

3.1 *Intervalling effect and beta stability*

One of the most crucial aspects when measuring beta coefficients is that the betas are stable over time. This is especially interesting because of the fact that if betas are highly unstable, their usefulness as risk measures decreases. If betas are unstable and investors make their portfolio decisions based on historical return series, they are likely to fail. In addition, if betas change over time, to hold the same systematic risk level in his portfolio, an investor has to revise his portfolio continuously.

The numerous tests of the stability of beta coefficients have produced quite interesting results. As noted by Dimson and Marsh (1983: 757), betas of stocks listed on thin stock markets seem to be of markedly stable nature. In addition, it has been reported that daily returns would provide more stable beta estimates than weekly returns, and betas based on weekly returns would be more stable than betas measured from monthly return intervals. As suggested by Dimson and Marsh (1983), the impression of stability in estimated betas might thus be due to the persistence of differences in trading frequencies between stocks.

On Finnish data, most of the studies seem

Table 1. Basic statistical properties of the estimated beta coefficients.

	Mean	Std.dev.	Negative	
Daily data				
1971–1972	0.776	0.829	5	
1973–1974	0.835	0.395	—	
1975–1976	0.767	0.393	—	
1977–1978	0.881	0.590	1	
1979–1980	0.829	0.472	—	
1981–1982	0.681	0.390	1	
1983–1984	0.628	0.320	—	
1985–1986	0.749	0.363	—	mean 0.768
Weekly data				
1971–1972	0.770	0.472	1	
1973–1974	0.808	0.342	—	
1975–1976	0.799	0.482	2	
1977–1978	0.922	0.607	2	
1979–1980	0.822	0.497	—	
1981–1982	0.742	0.480	1	
1983–1984	0.766	0.416	2	
1985–1986	0.802	0.334	—	mean 0.804
Monthly data				
1971–1972	0.822	0.468	1	
1973–1974	1.016	0.479	1	
1975–1976	1.185	0.613	—	
1977–1978	1.045	0.717	2	
1979–1980	0.981	0.546	1	
1981–1982	0.688	0.580	4	
1983–1984	0.817	0.425	1	
1985–1986	0.856	0.438	1	mean 0.926

[5] *For the general estimation problems of the market model parameters, see e.g. Huang and Litzenberger (1988).*

[6] *When computing the earnings, the maximum level of depreciations permitted under the Business Income Tax in Finland have been applied (see Martikainen, Ankelo and Ruuhela 1990 for the effects of alternative depreciation methods on the earnings of Finnish companies). This is carried out to make firms comparable to each other, as suggested by the Finnish Credit Analysis Commission (see Yritystutkimusneuvottelukunta 1983). The main aim of this foundation is to standardise the accounting practices in Finland. For the distributional characteristics and proportionality of E/P-ratios adjusted according to these recommendations, see Perttunen and Martikainen (1990).*

to report beta stability when short return intervals are used (see e.g. Korhonen 1977, Savolainen 1987, BLL 1989). For example, BLL (1989) reported that the ranking of betas conveyed statistically significant information about the ranking of the betas in the consequent period when *daily* betas were used. Substantial stability of the estimated Finnish beta coefficients was thus found. However, part of this stability was reported to consist of differences in trading frequency and firm size.

In order to study the effects of alternative return intervals on the estimated beta coefficients, betas are determined using daily, weekly and monthly returns. The research period is divided into eight two-year subperiods from 1971 – 1972 to 1985 – 1986. In this section 38 stocks are included, i.e. all the stocks which have been listed for the whole research period in the Helsinki Stock Exchange (see sample 1 in appendix 1). The basic statistical properties of the betas are reported in table 1. The general trend, as could be expected from

Table 2. Spearman rank correlations between daily, weekly and monthly betas.

1971 – 1972	daily betas	weekly betas	monthly betas
daily betas	1.00	0.42**	0.08
weekly betas		1.00	0.64***
monthly betas			1.00
1973 – 1974	daily betas	weekly betas	monthly betas
daily betas	1.00	0.52***	0.03
weekly betas		1.00	0.43**
monthly betas			1.00
1975 – 1976	daily betas	weekly betas	monthly betas
daily betas	1.00	0.82***	0.15
weekly betas		1.00	0.20
monthly betas			1.00
1977 – 1978	daily betas	weekly betas	monthly betas
daily betas	1.00	0.79***	0.61***
weekly betas		1.00	0.78***
monthly betas			1.00
1979 – 1980	daily betas	weekly betas	monthly betas
daily betas	1.00	0.88**	0.32*
weekly betas		1.00	0.43**
monthly betas			1.00
1981 – 1982	daily betas	weekly betas	monthly betas
daily betas	1.00	0.78***	0.60***
weekly betas		1.00	0.75***
monthly betas			1.00
1983 – 1984	daily betas	weekly betas	monthly betas
daily betas	1.00	0.86***	0.80***
weekly betas		1.00	0.73***
monthly betas			1.00
1985 – 1986	daily betas	weekly betas	monthly betas
daily betas	1.00	0.77***	0.55***
weekly betas		1.00	0.52***
monthly betas			1.00

* statistically significant at 0.05 level of significance
** statistically significant at 0.01 level of significance
*** statistically significant at 0.001 level of significance

previous overseas empirical evidence, seems to be that betas estimated with a longer return interval have higher values.

A remarkable observation, noted also in several other studies on Finnish data, is that the average beta is clearly less than unity. This phenomenon is apparently mainly due to the value-weighted market index used in this study. The returns of small firms are less correlated with the large firm dominated value-weighted returns than the returns of large firms.

Next, the Spearman rank correlation coefficients between betas determined by three different return intervals are computed. These are the correlations of the ranks of the variables, i.e. in this case betas, and are determined using the number of observations and the difference of ranks in observations.[7] Results from this correlation analysis are reported in table 2. An interesting point to note is the low correlation between monthly and daily betas in early subperiods when trading in the Finnish stock market was extremely thin.[8] More recently, the correlation between monthly and daily betas has increased. The results obtained by weekly returns indicate relatively high correlations between daily as well as monthly betas.

The Spearman rank correlations for the betas from different periods were also calculated in order to find out if the so-called intervalling effect has some effect on the stability of the beta coefficients. The results from this correlation analysis are reported in table 3. Statistically significant Spearman rank correlation coefficients in 0.05 level of significance are written in bold text. The results indicate that the betas based on weekly and daily return intervals seem to be more stable than betas measured from monthly returns. One potential explanation would be that thin trading causes impression of the stability in these betas (for an analysis of this assumption see the next section).

Thus, the results support the previous empirical findings by BLL (1989), Savolainen (1987) and Korhonen (1977) supporting beta stability when short return intervals are used when computing the betas in the Finnish stock market. In addition, it should be noted that by lengthening the estimation period (i.e. increasing the number of observations on a given return interval), more stable estimates for betas are typically obtained (see e.g. Dimson and Marsh 1983 on U.K., and Martikainen 1990 b on Finnish data). If the »true» betas were stationary over time, better estimates would simply be obtained when longer estimation periods were used. However, changes in the companies' economic conditions also affect their betas,[9] and the optimal estimation period is thus dependent on the speed with which betas change over time.

3.2 Infrequent trading and beta stability

In this section the effects of thin trading on betas measured from different return intervals are studied. This is carried out by calculating the Pearson correlation coefficients between the estimated beta coefficients and the ratio indicating the number of days when trade for a stock has occurred divided by the number of total trading days in the Helsinki Stock Exchange during the period in question.[10] Unfortunately, the data base including information about the trading frequency starts only from the beginning of 1977. This is why no empirical analysis of this kind on betas measured before that day was possible. The correlation coefficients between the measure of irregular trading and betas measured from different return intervals are presented in table 4. As it can be seen, the effects of irregular trading are highest when betas based on daily returns are used. However, the difference between monthly and weekly returns is not extremely high.

The signs of the correlations in table 4 are as expected. As discussed earlier, a major implication of the intervalling effect is the non-synchronous bias when betas are estimated.

[7] *The Spearman rank correlations are determined using the following formula*

$$r_s = 1 - \frac{6 \Sigma d_i^2}{N^3 - N},$$

where d_i is the difference of the ranks in i^{th} observation, and N is the number of observations.

[8] *For the impact of trading frequency on Finnish stock return distributions over time, see Berglund and Liljeblom (1990).*

[9] *See Martikainen (1990 b) for a review.*

[10] *On the alternative variables reflecting thin trading see e.g. BLL (1989), and Dimson and Marsh (1983).*

Table 3. Stability of betas. Spearman rank correlations. Statistically significant correlations in 0.05 level of significance in bold text.

Daily data								
Period	71–72	73–74	75–76	77–78	79–80	81–82	83–84	85–86
71–72	**1.00**	**0.42**	0.30	0.17	0.15	0.00	0.04	0.29
73–74		**1.00**	**0.71**	**0.45**	**0.40**	0.04	0.18	**0.34**
75–76			**1.00**	**0.61**	**0.45**	0.22	**0.55**	**0.48**
77–78				**1.00**	**0.51**	0.27	0.29	**0.39**
79–80					**1.00**	0.20	**0.50**	**0.35**
81–82						**1.00**	**0.57**	**0.39**
83–84							**1.00**	**0.45**
85–86								**1.00**
Weekly data								
Period	71–72	73–74	75–76	77–78	79–80	81–82	83–84	85–86
71–72	**1.00**	**0.47**	**0.60**	**0.66**	**0.56**	0.05	0.13	0.22
73–74		**1.00**	**0.56**	**0.41**	**0.62**	0.12	**0.33**	**0.45**
75–76			**1.00**	**0.63**	**0.41**	**0.33**	**0.39**	**0.40**
77–78				**1.00**	**0.46**	0.23	0.26	**0.37**
79–80					**1.00**	0.19	**0.51**	0.27
81–82						**1.00**	0.31	**0.43**
83–84							**1.00**	**0.38**
85–86								**1.00**
Monthly data								
Period	71–72	73–74	75–76	77–78	79–80	81–82	83–84	85–86
71–72	**1.00**	0.08	0.25	**0.47**	0.23	0.12	0.30	0.16
73–74		**1.00**	−0.26	−0.17	0.25	−0.22	0.18	0.18
75–76			**1.00**	**0.48**	−0.11	0.18	0.26	0.05
77–78				**1.00**	0.21	0.18	0.21	0.06
79–80					**1.00**	0.23	0.25	−0.02
81–82						**1.00**	**0.58**	0.28
83–84							**1.00**	**0.42**
85–86								**1.00**

The measured variances will overstate the »true» unobservable variances and understate the »true» covariances for infrequently traded stocks, biasing their betas downward. Thus, assuming a large number of infrequently traded stocks, a positive relationship between trading frequency and betas should be expected.

Table 4. Correlations between trading frequency and estimated beta coefficients from three return intervals.

	Daily betas	Weekly betas	Monthly betas
77–78	0.44**	0.30	0.13
79–80	0.48**	0.56***	0.13
81–82	0.39*	0.28	0.29
83–84	0.65***	0.53***	0.45**
85–86	0.38*	0.24	0.36*

* statistically significant at 0.05 level of significance
** statistically significant at 0.01 level of significance
*** statistically significant at 0.001 level of significance

To study the effects of infrequent trading on the stability of betas measured from alternative return intervals, the cross-sectional variation of trading frequency was removed from the estimated betas using the following OLS regression:

$$(4) \quad \beta_i = \gamma_0 + \gamma_1 TF_i + \varepsilon_i$$

Thus, the betas were explained by the measure trading frequency. The residual term in equation (4) is thus assumed to represent the part of the betas where the betas' cross-sectional variation caused by differences in trading frequency across stocks is eliminated. In the following, these residuals are noted with $\beta_i - TF$. Table 5 shows the results of the stability analysis of these residuals.

The results in table 5 are clear. There seems not to exist stability in systematic risk estimates after first controlling for the cross-sectional variation of trading frequency across stocks. Thus, assuming that the association between trading frequency and beta estimates is caused by measurement bias rather than a »true» relationship between trading frequency and the systematic risk of a security, these results do not give very good impression of the predictability of »true» Finnish betas based on historical return series. Thus, the results support the findings Dimson and Marsh (1983) on U.K. data who reported that the persistence of differences in trading frequency between stocks led to an impression of beta stability. Similar results based on daily return intervals have also been reported by BLL (1989) when Finnish data was used.

Table 5. Stability of residual betas. Spearman rank correlations. Statistically significant correlations in 0.05 level of significance in bold text.

Daily data					
Period	77–78	79–80	81–82	83–84	85–86
77–78	**1.00**	0.30	0.11	−0.15	0.25
79–80		**1.00**	0.03	0.22	0.14
81–82			**1.00**	**0.45**	0.26
83–84				**1.00**	0.24
85–86					**1.00**
Weekly data					
Period	77–78	79–80	81–82	83–84	85–86
77–78	**1.00**	0.30	0.12	0.05	0.31
79–80		**1.00**	0.10	0.21	0.14
81–82			**1.00**	0.09	**0.33**
83–84				**1.00**	0.26
85–86					**1.00**
Monthly data					
Period	77–78	79–80	81–82	83–84	85–86
77–78	**1.00**	0.19	0.13	0.21	0.10
79–80		**1.00**	0.14	0.20	−0.03
81–82			**1.00**	**0.54**	0.16
83–84				**1.00**	0.24
85–86					**1.00**

3.3 Risk-return relationship and betas

Thus, in sections 3.1 and 3.2 it was reported that the selection of return intervals when measuring betas affects the values of the estimated betas and also their stability. In this section, it is analysed whether these drastic effects can explain some of the poor empirical results concerning the risk-return relationship suggested by the CAPM, and the so-called market anomalies which are direct deviations from the suggested linear risk-return relationship. Assuming the differences between betas were entirely due to larger standard errors of the betas based on longer return intervals, the betas based on longer return intervals should be less related to return variation. Considering the two major anomalies, the size-effect and the E/P-effect, it is tried to find out whether it is possible to reduce the existence of these anomalies by using »better» beta estimates.

In this section solely those firms which have had their ordinary share listed for the whole research period are analysed (see sample 2 in appendix 1). By concentrating solely on these firms, the problems measuring E/P-ratios for preference shares are eliminated. Thus, 27 stocks are included in the empirical analysis of this section. To test the linear risk-return relationship suggested by the CAPM,[11] a simple OLS procedure (5) is applied. Thus, the expected returns, R_{it}, (in this study measured as average weekly returns) on stock i for the period (t) are explained by the betas measured from the three return intervals based on security returns from the period $(t-1)$. The number of firms investigated is 27, i.e. $i = 1 \ldots 27$.

(5) $$R_{it} = \lambda_0 + \lambda_1 \beta_{it-1} + \varepsilon_{it}$$

The results of the cross-sectional explanatory power of the CAPM are summarized in Table 6. They indicate, in accordance with

[11] It is well known that the tests of the CAPM have typically not produced significant support to the model (for a couple of exceptions on U.S. data, see Fama and MacBeth 1973, and Black, Jensen and Scholes 1972) and alternative equilibrium models have also been created and tested. The most famous of these competitive models is apparently the Arbitrage Pricing Theory by Ross (1976), and on Finnish data tested by e.g. Östermark (1989), and Yli-Olli, Virtanen and Martikainen (1990).

Table 6. Explanatory power of the alternative beta estimates on the cross-sectional variation of expected stock returns.

	Daily betas	Weekly betas	Monthly betas
Returns measured from the period	Rate of determination of the model (5)		
77–78	0.051 (–)	0.068 (–)	0.098
79–80	0.163 (–)*	0.022 (–)	0.018 (–)
81–82	0.014	0.013	0.011 (–)
83–84	0.061	0.199*	0.077
85–86	0.068 (–)	0.110 (–)	0.119 (–)

F-value of the model:
* statistically significant at 0.05 level of significance
** statistically significant at 0.01 level of significance
*** statistically significant at 0.001 level of significance

(–) negative relationship between betas and expected returns

previous studies in the Finnish stock market, poor empirical applicability of the model when cross-sectional variation of expected returns are analysed. There may be several potential reasons for these relatively poor results.[12] In this context, however, the most interesting aspect is that the betas measured from the three alternative return intervals do not significantly produce a better explanation of the cross-sectional expected returns. Neither did the residual betas, $\beta_i - TF$, i.e. error terms from regression (4).[13]

The size effect was first discovered by Banz (1978). He reported that the smaller the market value of equity, the larger the expected rate of return on a stock, other things being equal. This puzzling finding has also been documented in several other stock markets later on (see e.g. Australia by Brown, Kleidon and Marsh 1983, Canada by Berges, McConnell and Schlarbaum 1984, Finland by Berglund 1986, and U.K. by Levis 1989). No adequate answer has yet been for this long-run negative effect of firm size on risk-adjusted stock returns. The most famous explanations of this phenomenon include the average returns for small firms being miscalculated (see e.g. Roll 1983), the CAPM to be misspecified (see e.g. Chen 1983), large transaction costs with small firms (see e.g. Stoll and Whaley 1983), and market betas being misestimated (see e.g. Roll 1981). From the point of view of this study, the hypothesis of market betas being not properly estimated is the most interesting one. Empirical findings by Reinganum (1981), Chan and Chen (1988), and Handa, Kothari and Wasley (1989) give support to this explanation as a significant underlying reason for the size-effect.

The E/P-anomaly was first found by Basu (1977). According to his results, a distinct positive relation between E/P-ratios and average returns in excess of those predicted by the CAPM could be found on U.S. markets. This anomaly has also been discovered in many other studies later on (see Dimson 1988 for a review). On Finnish data, however, the results concerning this anomaly are rather limited.[14] It should be emphasized that most of the studies have been reported the size-effect and the E/P-anomaly to be highly related to each other, and also to other anomalies, such as the so-called January-effect (see e.g. Jaffe, Keim and Westerfield 1989).

As it has been suggested that the observed size-effect may not be linear (see e.g. McDonald and Miller 1989), a logarithmic form of the market value of equity is also used in the empirical analysis in this section. It should be noted that the sample which is used here in this section is again a reduced sample from the sample 1 used in sections 3.1. and 3.2. (see sample 2, appendix 1). In this section financial firms, and the firms not having their common stock listed in the Helsinki Stock Exchange are excluded from the sample.

To study the size- and E/P-anomalies,[15]

[12] *See e.g. Copeland and Weston (1988), and Huang and Litzenberger (1988) for a review.*

[13] *These results are obtainable from the author on request.*

[14] *For an exception, see Yli-Olli and Virtanen (1989) who found that the E/P-ratios seem to priced even after first controlling for the risk components of the APT in the Finnish stock market.*

[15] *The correlations between betas and E/P-ratios did not give support to any stable relationship between betas and the E/P-ratios of the firms. Theoretically, a positive relationship between E/P-ratios and betas could be expected. Concerning the association between market values of firms and betas, the results seemed a bit more interesting indicating a rather stable positive relationship between estimated betas and market values of companies. Theoretically, no relationship between beta and firm size should exist. Typically, a negative relationship between betas and*

Table 7. Correlations between E/P-ratios, firm size and error term in (5).

	77–78	79–80	81–82	83–84	85–86
	E/P-ratio				
monthly betas	0.58**	−0.01	0.36	0.21	−0.50**
weekly betas	0.46*	−0.02	0.31	0.20	−0.52**
daily betas	0.48**	−0.09	0.32	0.12	−0.51**
	Market value of equity				
monthly betas	−0.20	−0.21	−0.38*	−0.11	−0.13
weekly betas	−0.12	−0.17	−0.44*	−0.11	−0.17
daily betas	−0.13	−0.07	−0.44*	−0.05	−0.14
	Natural logarithm of the market value of equity				
monthly betas	−0.30	−0.30	−0.34	−0.09	−0.18
weekly betas	−0.14	−0.25	−0.41*	−0.07	−0.21
daily betas	−0.16	−0.14	−0.41*	−0.03	−0.19

* statistically significant at 0.05 level of significance
** statistically significant at 0.01 level of significance
*** statistically significant at 0.001 level of significance

the part of the expected returns which is not explained by the estimated betas, i.e. the residual term in (5) is first focused. Table 7 presents the correlations between these residual terms and the E/P-ratios and the two measures for firm size measured from the beginning of the five subperiods. The results are quite interesting. First of all, the results indicate a negative relationship between the residual term in (5) and firm size. Thus, the size-anomaly is again supported in this context. However, it should be noted that the correlations are typically not statistically significantly ($p = 0.05$) different from zero, excluding the period 1981–82 where the correlations are clearly significant. The low correlations are apparently due to the facts that (1) relative short estimation periods are used, and (2) individual stocks instead of portfolios typically used in previous research projects concerning the size-effect are investigated.

Concerning the E/P-anomaly, the results are not as clear. In the first subperiod, 1977–78, a positive relationship between the E/P-ratios and risk-adjusted stock returns seems to have existed. On the other hand, the relationship in the last subperiod, 1985–1986, indicates a negative E/P-effect. This finding on the negative connection between earnings and stock returns in these years in the Finnish stock market has also been reported in recent studies by Martikainen (1990 a), and Martikainen, Ankelo and Ruuhela (1990). Thus, the E/P-effect seems to be clearly more unstable than the size-effect in the Finnish stock market.

Concerning the alternative beta estimates, the results are not markedly different from one another. Thus, it seems that the selection between daily, weekly or monthly return intervals does not lead to significant changes in the E/P- and size-anomalies. To investigate whether the anomaly can be more clearly found when longer research periods are investigated, the association between market-adjusted returns,[16] i.e. $R_{it} - R_{mt}$, and the E/P-ratios and size measures were also studied for the whole research period 1977–1986. Thus,

firm size has been reported on several studies on U.S. data (see e.g. Friend and Lang 1988, and Handa, Kothari and Wasley, 1989). In Finland, however, the association between estimated betas and firm size seems to be positive (see also Berglund and Wahlroos 1983 for the same kind of conclusion). This kind of conclusion has also been reported for several other smaller, European security markets. The positive relationship between betas and firm size in Finland could well be due to infrequent trading, which makes the betas of infrequently traded stocks (typically small firms) underestimated. This assumption is also supported by the findings of a negative relationship between betas and firm size on the U.S. markets where a considerably larger number of stock is listed, and trading is more frequent by nature.

[16] *See e.g. Liljeblom (1989) for the alternative ways to estimate abnormal returns.*

Table 8. Correlations between E/P-ratios, firm size and market adjusted returns.

	Market-adjusted returns from the period	
	1977 – 1986	1977 – 1984
E/P-ratio	0.28	0.46*
Market value of equity	–0.38*	–0.33
Natural logarithm of the market value of equity	–0.42*	–0.38*

* statistically significant at 0.05 level of significance
** statistically significant at 0.01 level of significance
*** statistically significant at 0.001 level of significance

using market-adjusted returns, it was assumed that the »true» betas across stocks equal unity. This simplifying assumption was carried out in this context due to the serious problems in the estimates of betas reported earlier.

Table 8 presents the correlations between the average market-adjusted returns and the E/P-ratios and the measures for firm size based on the values of 31.12.1976. The average market adjusted returns for stocks are measured from two periods 1977 – 1986, and 1977 – 1984, due to the exceptional behaviour of the period 1985 – 1986 reported above. The results reveal that both of the effects can be found in the Finnish stock market in the long-run. The E/P-effect, however, is found to be more unstable in nature.[17]

[17] *The incremental information of these two effects was also studied, by explaining the market-adjusted returns for the period 1977 – 1984 by the logarithm of the market value equity and the E/P-ratio measured from the beginning of the research period. The two effects explained as much as 31.2 per cent of the total cross-sectional variation on market-adjusted returns on that period. The T-values for the regression coefficients were 2.397 (E/P-ratio) and –1.842 (Market value). The F-value of the regression equation was clearly significant, 5.444. The correlation between the two independent variables was less than 0.1, so the multicollinearity was no problem in this context. Thus, the results supported the findings by Cook and Rozeff (1984), and Levis (1989) on U.S. and U.K. data, respectively. Thus, the effects to be incrementally important to one another. Further research is, however, needed to relate the findings, for example, with another anomalies, such as the January effect (see e.g. Jaffe, Keim and Westerfield 1989).*

4. Summary and conclusions

This paper focused the effects of infrequent trading on common stock systematic risk estimates based on daily, weekly and monthly return intervals using Finnish data. Significant trading frequency effects on values of betas were reported. These were assumed to be caused by the effects on nonsyncronous trading bias when measuring returns. Because of nonsyncronous trading, measured returns do not cover identical time periods. This leads to the underestimation of the betas of infrequently traded stocks. The effects of infrequent trading were found to be strongest when daily return intervals were used in beta estimation. In addition, it was found, in accordance with the overseas results, that betas measured from longer return intervals have higher values than betas based on daily returns.

Concerning the stability of the estimated betas, the betas based on weekly and daily returns were found to be substantially more stationary than the betas based on monthly returns. However, after first controlling for the cross-sectional variation in trading frequency across stocks, the stability of these betas was significantly reduced. This supports the finding by Dimson and Marsh (1983) that the impression of stability in beta estimates on small stock markets is primarily due to the persistence of differences in trading frequencies between stocks.

The implications of infrequent trading were also evaluated in the context of the linear risk-return relationship suggested by the CAPM, and especially in the context of the two widely discussed anomalies, the size-effect and the E/P-effect. The alternative beta estimates did not produce significantly better results concerning the applicability of the CAPM in Finland. Both of the anomalies were found irrespective which of the three return intervals were used in the tests when computing the betas. Concerning the two anomalies, some interesting results were reported. Firstly, relatively long research periods are required before the anomalies can be found. Secondly, especially the E/P-anomaly seems to be somewhat unstable by nature. Finally, the two anomalies were found to be incrementally significant with respect to each other.

The results indicate that the association between trading frequency and beta estimates is caused by measurement bias rather than a »true» relationship between trading frequency and the systematic risk of a security. This questions the usefulness of historical return series in beta estimation on the Finnish stock market. Thus, in further research the use of instrumental variables (such as accounting betas) in risk estimation should be considered more carefully in the Finnish stock market.[18]

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[18] *See Martikainen and Perttunen (1990) for some encouraging results in this context.*

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Appendix 1.

Firms included in the study.
S1 = included in the Sample 1.
S2 = included in the Sample 2.

Effoa	Effoa-Finland Steamship Co Ltd. S. K	S1	S2
Enso A	Enso-Gutzeit Ltd S. A	S1	S2
Enso R	Enso-Gutzeit Ltd S. R	S1	
Fiskars	Fiskars-Corporation	S1	S2
Ford	Ford Corporation	S1	S2
Huhtamäki	Huhtamäki Corporation S. K	S1	S2
Kajaani	Kajaani Corporation	S1	S2
Kemi	Kemi Corporation	S1	S2
Kesko	Kesko Corporation	S1	S2
Kone	Kone Corporation S. B	S1	
KOP	Kansallis-Osake-Pankki	S1	
Kymi	Kymmene Corporation	S1	S2
Lassila	Lassila & Tikanoja Ltd	S1	S2
Lohja	Lohja Corporation S. A	S1	S2
Metsa	Metsäliitto S. B	S1	
Nokia	Nokia Corporation	S1	S2
Otava	Otava Publishing Company Ltd	S1	S2
Partek	Partek Corporation	S1	S2
Pohjola	Pohjola Insurance Company Ltd. S. A	S1	
Rauma	Rauma-Repola Corporation	S1	S2
Rosenlew	Rosenlew Corp. S. A	S1	S2
Scha K	Schauman Corp. S. K	S1	S2
Scha E	Schauman Corp. S. E	S1	
Serla A	G.A. Serlachius S. A	S1	S2
Serla B	G.A. Serlachius S. B	S1	
Sokeri	Finnish Sugar Co Ltd S. I	S1	S2
Stockmann	Stockmann S. A	S1	S2
S.Trikoo	Suomen Trikoo Corp. S. A	S1	S2
SYP A	Union Bank of Finland Ltd S. A	S1	
SYP B	Union Bank of Finland Ltd S. B	S1	
Tamfelt	Tamfelt Group S. K	S1	S2
Tampella	Tampella Ltd	S1	S2
Tamro	Tamro Ltd S. K	S1	S2
TOK	Talous-Osakekauppa Co	S1	S2
Wartsila I	Wärtsilä Co. S. I	S1	S2
Vartsila II	Wärtsilä Co S. II	S1	
Yhtyneet	United Paper Mills Ltd S. K	S1	S2
AAB	Bank of Åland Ltd S. K	S1	