Journal of Finance and Bank Management
June 2015, Vol. 3, No. 1, pp. 117-133
ISSN: 2333-6064 (Print), 2333-6072 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jfbm.v3n1a11
URL: http://dx.doi.org/10.15640/jfbm.v3n1a11

Size, Beta, Average Stock Return Relationship, 19th century Evidence

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Abstract

We used portfolio sorting and Fama-MacBeth cross-sectional regression approach to test the validity of the Capital Asset Pricing Model (CAPM) in the 19th century. The CAPM is not valid in the 19th century, but we caution not to discard the model completely. Since the high fluctuations in the times' series of the slopes (coefficient of the relationship between expected returns and beta) cover the capability to reach a solid conclusion concerning validity of the CAPM. Size (price time's shares outstanding) effects exist on the 19th century, but it disappears when stocks are value weighted to form portfolios. Detail evidence reveals that size effect is contributed by small size group of stocks, which accounts for only 0.35% of the total market size.

Keywords: Beta, Size-Effect, Portfolio, CAPM, 19th Century, Stock Markets, History

Introduction and Literature Review

This paper investigates the cross-sectional relationship between stock returns, beta and size measured as market capitalization. We use 19th century Belgium data. It might be interesting to research these cross-sectional relationships on contemporary markets; however, this might not add independent information in an integrated global market. It is possible that, because of the common shocks, similar relationships will be visible across different markets. Therefore, studying the cross-sectional relationship in an independent but large non-US 19th century market may provide strong out of sample evidence.

Since the development of the CAPM in the 1960s by Sharpe (1964), Lintner (1965) and Mossin (1966), the literature has questioned the validity of the model and suggest other characteristics than beta to explain expected return. The empirical study which supports the CAPM model in the 1970s is Fama and MacBeth (1973). It investigates whether there is a positive linear relationship between expected returns and beta. They also examine whether other parameters such as beta square and idiosyncratic risk can explain expected returns. On the contrary, Lakonishok and Shapiro (1986) and Ritter and Chopra (1989) do not detect any significant relationship between beta and expected returns. On the relationship between expected returns and size, Banz (1981) finds a size effect in stock returns. The effect implies the propensity for stocks with low market capitalization to outperform those with high market capitalization. With the debate on the validity of the CAPM still ongoing, Fama and French (1992)nailed beta in the coffin by finding no association between betas and average returns, even when beta is the only explanatory variable in their cross-sectional regressions. Instead, they conclude that size and the book-to-market value ratio can explain the variation in expected returns when placed together in a cross-sectional regression. Majority of the literature on beta and size focuses on post-World War I return data and even only in the US. The view is that, the determination of stock return using beta and size may have been discovered out of luck through data snooping bias (see Lo and MacKinlay (1990)). In this case, the effect should not be found in other periods.

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Dimson and Marsh (1999) test the presence of the size effect by using FTSE all share monthly return data from the period 1955 to 1998 and document that the effect has disappeared after 1979. In addition, Schwert (2003) documents that the size effect disappears after 1981 on the US market using monthly data for the period 1962 to 2002.Harowitz el al. (2000) provides three possible explanations for the disappearance of the size effect: (1) data mining (2) the increased popularity of the passive investment which would have driven up prices of large companies and (3) the awareness of investors after publication of the research results has eliminated profit opportunities.Grossman and Shore (2006) and Annaert and Mensah (2014)in their quest to establish these relationships out of sample, use pre-World War I UK and Brussels Stock Exchange data respectively to present evidence against the size effect. They find size effect among extremely small stocks, which account for about 0.2% to 0.35% of market capitalization, but the size effect disappears when these stocks are eliminated. Further investigation by Ye and Turner (2014) finds stock return to be related to beta but not size.

To distinguish between the possible data snooping bias and the persistence of these relationships, we investigate the effect on another dataset. This is to investigate whether; the size-beta-stock return relationship is initially discovered outside the existing study. To add to the existing literature on asset pricing, this paper introduces high quality 19th century Brussels Stock Exchange (BSE) data to test the validity of CAPM and the presence of the size effect. We investigate this historical data to differentiate between the rational asset pricing and the behavioral finance phenomena. Thus, using periods of severe economic and financial distress to investigate the behavior and the tradability of the patterns found. In addition, investigating such relationship using database not infested with any data mining act and also capturing a period (1873-1914) of which the exchange was ranked the top 10 in the world (Cassis (2006))may help to shed some light on the size, beta, stock return relationship issues, as well as indirectly testing the data-snooping hypothesis. It will also provide dataset for testing the alternate rationalization of other cross-sectional patterns. This paper presents large improvement over other studies on historical markets by considering both equal and value weighted portfolio formations.

To this end, we resort to the decile portfolio sorting and the Fama-MacBeth (FM)cross-sectional regression methods to investigate the relationship between size, beta and the averagestock return. We find no relationship between beta and expected returns. We also find size effect on the 19th century BSE, but it disappears when stocks are value weighted to form portfolios. Detailed investigation reveals that the size effect in our data is confined to small size stocks, which represents on average 0.35% of the total market capitalization. The remainder of the paper is organized as follows: In section 2, we show the expected returns of portfolios sorted on Market Model betas (β_{MM}), Dimson's betas (β_D) and Vasicek betas (β_V). FM cross-sectional regressions are used to test the relationship between beta and expected returns (CAPM) in subsection 3. In section 4, we investigate the effect of size and beta on excess returns by using the sorting method. In section 5, we use FM cross-sectional regression analysis to confirm the above sorting results. Section 6 concludes the paper.

Expected Returns of Portfolios Sorted on Betas

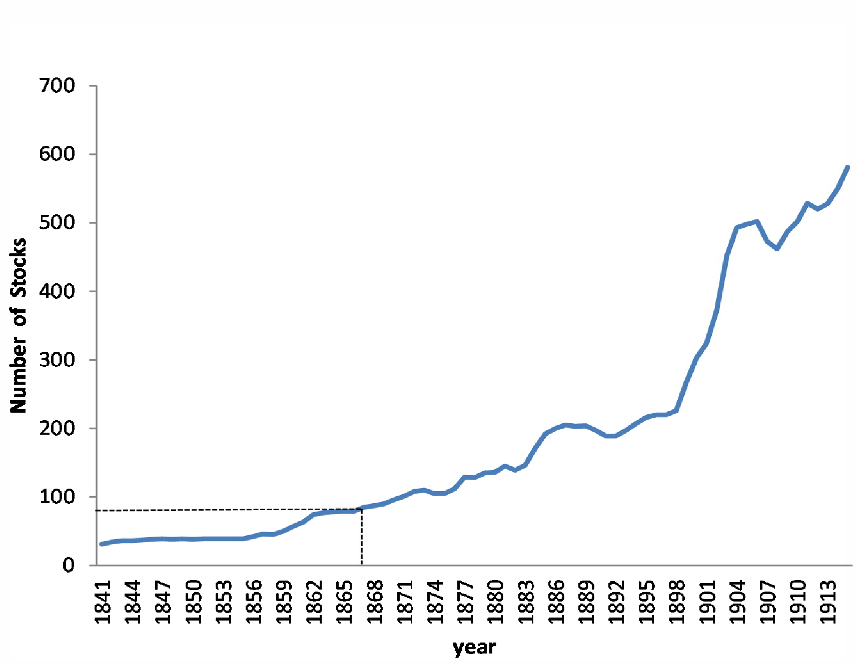
In the sorting method, we rank stocks based on beta and group them to form portfolios. The question answered by this method is whether high-beta stocks outperform low-beta stocks. As the aim of this section is to test the validity of the CAPM, the method needed to estimate its input is worth consideration. In testing the CAPM, one needs to form portfolios in order to improve on the precisions of individual betas. Previous research on the same data Mensah (2013) indicates that beta-sorted portfolio should contain at least seven stocks in order to have a reliably stable portfolio beta estimate. Figure 1 shows the number of stocks that is included in our sample for portfolio formation every year. Evidence from this Figure shows that until 1868 decile portfolios will not have the minimum of seven stocks. The changes in legislation in 1867 ease the establishment of a company, which is reflected in the number of stocks listed on the BSE. Furthermore, Van Nieuwerburgh et al. (2006) indicate the importance of the long-term relationship between the development of the BSE and economic growth in Belgium after legal liberalization.

In addition, as shown Mensah (2013), individual betas before 1868 do not predict well their subsequent five-year beta. Based on these reasons, this section and the subsequent ones will focus on the data between 1868 and 1914. For a stock to be included in the portfolio formation, it must have a minimum of 24-month observations out of the 60 months required to estimate beta before the portfolio formation year. In this paper, we do not restrict our analysis on stocks with a complete five-year return data as done by other papers. This enables us to capture more stocks in the cross-section. Including stocks with at least 24 months returns does not change the descriptive statistics of the prior betas (from here on pre-ranking betas).We pay particular attention to the computation of the beta as the 19th century stock markets were less liquid than their modern counterpart. The first is the market model (β_{MM}) beta, which is the traditional beta. It is the slope coefficient from the regression equation

$$R_{jt} - R_{ft} = \alpha + \beta_{MM}\left(R_{mt} - R_{ft}\right) + \varepsilon_t \text{ , (1)}$$

where R_{jt} is the return on a portfolio or stock for period t, R_{ft} is the risk free rate for period t, and R_{mt} is the market portfolio for period t.

Figure 1: Number of Stocks in Our Selection Criteria for the Entire Period of the Pre-World war I SCOB



We use the value weighted market portfolio constructed by Annaert et al. (2012) as a proxy for the market portfolio. The annualized money market rate, converted to a monthly-rate, is used as a proxy for the risk-free rate. We compute the second beta estimate using the Vasicek model. Vasicek (1973)applied the Bayesian correction method by utilizing the cross-sectional information of the previous period betas:

$$\beta_{jt} = \frac{\frac{\bar{\beta}_{jt-1}}{\operatorname{var}\left(\beta_{jt-1}\right)} + \frac{\beta_{jt-1}}{\sigma_{\beta}^{2}}}{\frac{1}{\operatorname{var}\left(\beta_{jt-1}\right)} + \frac{1}{\sigma_{\beta}^{2}}} \quad \text{for } j = 1, 2, \ldots, N \text{ , (0.2)}$$

where β_{jt} is the mean of the posterior distribution of beta for stock j, which serves as the beta forecast. σ_{β}^{2} is the variance of the market model regression coefficients, β_{jt-1}. $\bar{\beta}_{jt-1}$ is the cross-sectional mean of betas in period $t-1$, and $\operatorname{var}\left(\beta_{jt-1}\right)$ is the variance in the cross-section of betas. As a result of the illiquidity on the early markets, some stocks systematically may lead or lag behind the market movement, which may produce biased betas, when we estimate beta by the market model. Possible explanation for the significant lead (lagged) relationship is because large (small) firm prices adjust quickly (slowly) to market wide information. Thus, since the market index used in this analysis is heavily weighted towards large stocks, small stock returns have the tendency to lead or lagged relation to the market wide returns. We adjust for the lag effect by using the Dimson model to obtain a third beta estimate.

That is, we run the regression:

$$R_{jt} - R_{ft} = \alpha_{j} + \beta_{j,0}\left(R_{mt} - R_{ft}\right) + \beta_{j,-1}\left(R_{mt-1} - R_{ft-1}\right) + \delta_{jt} \text{ , } \quad (0.3)$$

where $\beta_{j,0}$ captures the contemporaneous co-variation between the returns of a stock (portfolio) and the market returns. $\beta_{j,-1}$ captures the correlation between stock's current period return and the lagged market return. The Dimson one-month lagged beta is estimated as $\beta_{dim} = \beta_{j,0} + \beta_{j,-1}$, which captures the correlation between the current period returns of a stock and current and lagged market returns. For our monthly data, we use only one-month lag because it has been shown that infrequent trading effect is not a severe problem in our data. In addition, Dimson (1979) document that the infrequent trading effect is not severe when monthly returns are used to estimate betas.

Stocks are assigned to decile portfolios using the Fama-MacBeth[2] breakpoint method. This breakpoint method allocates more stocks to the extreme portfolios, which are of much interest because of the formation of the hedge portfolio (top ranked portfolio returns minus bottom ranked portfolio returns). The method also ensures that no stock is lost in the portfolio formation process. Fama and MacBeth (1973) point out that portfolios formed on prior betas are more likely to produce biased betas, since high and low betas are more likely to be estimated with errors. To reduce the possible errors in beta estimates, we resort to Fama and French (1992) and Kothari, et al. (1995) method to estimate post-ranking betas. We estimate post-ranking portfolio betas for the entire sample period (1868-1914) by using value weighted and equally weighted portfolio returns. Specifically, beginning in January 1868, we compute betas (pre-ranking) for all stocks using the past 24 to 60 months of return data. We sort stocks into decile portfolios based on the pre-ranking betas (univariate sort). Portfolio 1 contains stocks with the lowest betas, while portfolio 10 contains stocks with the highest betas. The post-ranking value weighted and equally weighted return for each month is calculated for each portfolio.

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[2] If N is the number of stocks in the year t and n is the number of portfolios required, stocks are allocated to $\operatorname{int}(N/n)$ portfolios, where $\operatorname{int}\left(N/n\right)$ is the nearest integer less or equal to N/n. The middle portfolios have $\operatorname{int}\left(N/n\right)$ stocks each. If N is even, $\operatorname{int}\left(N/n + 1/2\left[N - n \times \operatorname{int}\left(N/n\right)\right]\right)$ stocks will be allocated to the first and the last portfolio. If N is odd, one stock will be added to the last portfolio.

New estimates of pre-ranking betas are calculated in December each year, and the portfolio formation is repeated. We account for the possible time-variation in betas by rebalancing stocks in each year. Monthly portfolio formation for each year yields 552 monthly returns for each decile portfolio. This process is followed for all the three beta estimates $\left(\beta_{MM}, \beta_V \text{ and } \beta_{dim}\right)$. Table 1 reports the average excess return (time series), standard deviation and the post-ranking betas of the ten portfolios. From Panel A, when both pre-ranking and post ranking betas are estimated with the market model, beta does not exhibit any relationship with average returns. The average returns do not show any pattern as beta progressively increases from low to high beta portfolios. The result does not change, when we consider the value weighted portfolio excess returns. Estimating betas with the Dimson and Vasicek methods in Panels B and C does not establish the relationship between beta and expected returns. The most striking of all is that the post-ranking betas almost surely follow the ordering of the pre-ranking betas (except the first, second and the sixth decile portfolios). The univariate beta sorting results confirm the Fama and French (1992) findings. They use Dimson adjusted betas to establish a flat relationship between beta and average return. We can also compare our result to the evidence of Reinganum (1981) who finds no relationship between beta and average return in the period 1964-1979.

Table 1: Time Series Mean (%), Standard Deviation (%) and Post-ranking Betas of Decile Portfolios formed from Pre-Ranking Betas in Jan. 1868-Dec. 1914

	Low 1	2	3	4	5	6	7	8	9	High10
					Panel A					
Market Model (Equally Weighted)										
Mean (%)	0.34	0.13	0.18	0.45	0.45	0.25	0.32	0.23	0.09	0.26
Standard Deviation(%)	3.91	2.14	1.93	2.88	3.14	3.22	3.68	3.82	4.71	6.67
Beta	0.68	0.45	0.53	0.82	1.10	1.19	1.49	1.60	1.94	2.68
Market Model (Value Weighted)										
Mean (%)	0.17	0.18	0.09	0.12	0.40	0.36	0.27	0.16	-0.06	0.05
Standard Deviation(%)	3.17	1.22	1.62	2.02	2.82	2.90	3.06	3.34	4.07	5.66
Beta	0.62	0.33	0.41	0.67	1.01	1.21	1.33	1.45	1.80	2.48
					Panel B					
Dimson Betas(Equally Weighted)										
Mean (%)	0.18	0.30	0.28	0.26	0.20	0.30	0.35	0.23	0.26	0.32
Standard Deviation(%)	3.02	3.12	2.33	2.64	3.00	3.07	3.61	4.12	5.13	6.38
Beta	0.71	0.64	0.61	0.95	1.26	1.23	1.48	1.71	2.14	2.49
Dimson Betas(Value Weighted)										
Mean (%)	0.06	0.33	0.17	0.32	0.18	0.26	0.30	0.03	0.14	-0.05
Standard Deviation(%)	1.63	3.35	1.50	1.95	2.79	2.45	3.08	3.56	4.52	5.48
Beta	0.39	0.58	0.45	0.75	1.13	0.98	1.32	1.56	1.92	2.32
					Panel C					
Vasicek Betas(Equally Weighted)										
Mean (%)	0.25	0.23	0.26	0.43	0.37	0.25	0.30	0.23	0.20	0.17
Standard Deviation(%)	3.59	2.32	2.04	3.08	3.09	3.22	3.68	4.70	5.09	5.58
Beta	0.92	0.93	0.92	0.97	1.10	1.19	1.45	1.58	1.57	1.55
Vasicek Betas(Value Weighted)										
Mean (%)	0.20	0.13	0.12	0.19	0.36	0.36	0.20	0.17	0.06	0.01
Standard Deviation(%)	2.79	1.24	1.47	2.34	2.71	2.90	3.36	3.39	4.35	4.66
Beta	0.80	0.81	0.81	0.86	0.99	1.21	1.36	1.37	1.41	1.39

At the beginning of each year, stocks are sorted based on pre-ranking betas. The pre-ranking betas are estimated with market model (β_{MM}), Vasicek's adjustment (β_V) model and the Dimson's model with one month lag (β_{dim}). The Fama-MacBeth breakpoint technique is used to assign stocks to decile portfolios. Portfolio 1 contains the lowest betas and Portfolio 10 contains the highest betas. Mean (%) is the time series average of the portfolio excess returns for the entire period.We compute time series Standard Deviation(%) of the post-ranking excess returns. Betas are estimated by using the long time series portfolio excess returns and the corresponding excess market returns.

The Cross-Sectional Regressions

The standard approach to test the validity of the CAPM is the sorting and the FM (1973) cross-sectional regression. In this section, we use the FM cross-sectional regression to test the robustness of the above sorting result. The FM approach also provides a straightforward procedure to test whether the reward for bearing beta risk (risk premium) is equal to the excess market returns (the return of the market less the risk free rate) as implied by the Sharpe, Lintner and Mossin version of the CAPM. The method also considers the noisy nature of portfolio or stock returns by running monthly cross-sectional regressions of beta sorted portfolio returns on betas. That is,

$$R_{jt} - R_{ft} = \gamma_{0t} + \gamma_{1t}\beta_{jt} + \eta_t \qquad (0.4)$$

where γ_{0t} and γ_{1t} are the regression intercept and slope for month t respectively. β_{jt} is the beta estimated from the full sample portfolio returns. The slope coefficient from each regression is treated as the reward per unit of the beta risk in that month (risk premium). The time series average of the monthly coefficient is the average reward for bearing the beta risk. The standard deviation of the monthly time series of slopes is used to perform a t-test, whether the average slope is statistically significant from zero, in other words, whether the beta risk is priced on average. Fama and French (1992)rely on full window portfolio betas to mitigate the error-in-variable problem. Moreover, it is common to rely on large sample size statistics to draw inferences. This curbs the argument that the test can be incorrect if the size of the sample is not large enough for the asymptotic results to provide a good approximation. We adopt the method by Fama and French (1992) to estimate full window portfolio betas. The only difference is that, we replicate Ibbotson et al. (1997) method and use the portfolio betas for the cross-sectional regression instead of assigning the portfolio beta to individual stocks in the portfolio each year. As in the previous section, we sort stocks based on their estimated pre-ranking betas (Market model, Vasicek and Dimson betas) and form portfolios each year. Portfolio 1 contains the lowest beta stocks whiles portfolio 10 contains highest beta stocks. We form equally weighted and value weighted portfolios from the beta sorted group of stocks each month. We repeat the process each year to account for time variations in betas. This will produce 552 monthly returns of decile portfolios (post-ranking returns).

Table 2: Average Time Series Slopes from the Fama-MacBeth Cross-Sectional Regressions in Jan. 1868-Dec. 1914

Intercept	β_{MM}	β_{dim}	β_V	t-test H0:Slope=(R_m-R_f)
Panel A: Equally Weighted Portfolio				
0.30%	-0.02%			1.41
(2.49)	**(-0.17)**			
0.24%		0.02%		0.93
(1.87)		**(0.14)**		
0.42%			-0.12%	1.05
(1.57)			**(-0.43)**	
Panel B: Value Weighted Portfolios				
0.24%	-0.06%			2.16
(2.92)	**(-0.48)**			
0.30%		-0.11%		2.63
(3.41)		**(-0.80)**		
0.28%			-0.10%	0.94
(1.19)			**(-0.33)**	
Panel C: Individual Stocks				
0.29%	-0.01%			1.47
(2.37)	**(-0.16)**			
0.26%		0.02%		1.16
(2.10)		**(0.29)**		
0.36%			-0.06%	1.55
(2.70)			**(-0.41)**	

This table reports average time series slopes and intercepts from monthly cross-sectional regression of post-ranking portfolio excess returns on post-ranking beta estimates. It also shows the hypothesis test of mean slope (risk premium) equal to the average excess market returns as implied by the Sharpe-Lintner CAPM. Newey West adjusted t-statistics are in parentheses. β_{MM}=Market Model beta, β_V=Vasicek beta and β_{dim}=Dimson's beta with one month lag.

The post-ranking betas are estimated by using the post-ranking long time series' returns of the decile portfolios. We repeat the process for the various estimates of betas $(\beta_{MM}, \beta_V, \beta_{dim})$. The post-ranking beta serves as the input for equation 1.4 above to perform the cross-sectional regressions. Each month, we regress the post-ranking excess returns of the decile portfolios on their corresponding beta (post-ranking) estimates. Eventually, we obtained 552 cross-sectional regressions for each estimate of beta. After performing the monthly cross-sectional regressions, the time series mean of the slope coefficients is tested for statistical significance. The significance of the average slope is tested by using heteroskedastic and autocorrelation consistent standard errors (Newey and West (1987) correction with default lag of int ($T^{1/4}$), where T is 552).

Table 2 reports the average intercepts, slopes and their corresponding t-statistics in parentheses. As shown by the sorting method, Panel A indicates that, the market model post-ranking beta, estimated with equally weighted portfolio returns does not provide a significant relationship with returns. Estimating pre-ranking and post-ranking betas with Vasicek and Dimson method does not revive the beta return relationship. Specifically, in Panel A, the mean estimated slope for the market model beta is negative, and it is only 0.17 standard errors from zero. The negative slope is quite surprising as it goes against the notion of positive risk premium (CAPM). Fama and French (1992) had a negative slope for beta when placed together with size in the cross-sectional regression. The average slope using the Dimson beta is 0.02% with a t-statistic of 0.14. The estimated mean slope with the Vasicek beta is also not significant. The values in the last column show the t-statistics from the hypothesis test of average slope (risk premium) equals the average excess market return as implied by the CAPM. In Panel A, the hypothesis cannot be rejected at the 5% level, regardless how beta is estimated. However, it may be possible that the result is influenced by small stocks, since equally weighted portfolios give undue weight to small stocks. Therefore, in Panel B, we use value weighted portfolios for the estimation of post-ranking betas and in the cross-sectional regression. The average slope of all the beta estimates in the cross-sectional regression is significantly not different from zero. The most strikingly, the hypothesis of equality between the average slope and the average excess market return is rejected at the 5% level for the market model and the Dimson betas. In Panel C, we follow the traditional FM (1973) rolling window approach by using individual pre-ranking betas in the cross-sectional regression.

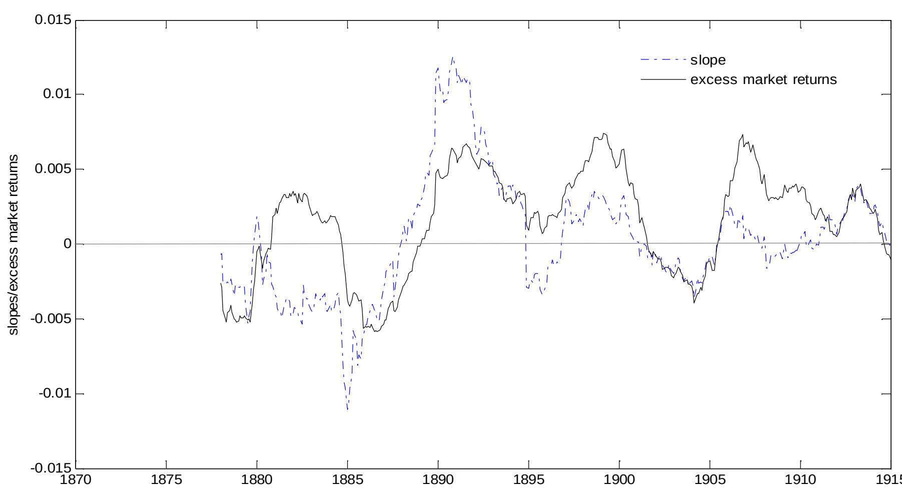
This is a predictive test since the pre-ranking betas are estimated over a period prior to the period over which the cross-sectional regression is performed. The results do not support the CAPM for the three beta estimates. Although, portfolio betas are used for the cross-sectional regression, others believe that portfolios may conceal important information contained in the individual stock betas. For example, Ang, Liu and Schwarz (2008) show that the slope coefficient (risk premium) of the cross-sectional regression can be estimated more precisely using individual stocks instead of portfolios, because creating portfolios reduces the cross-sectional variation in betas. As a result, we apply the Fama and French (1992) approach of estimating full window portfolio beta and assigning the portfolio beta to the individual constituent stocks of the portfolio in the cross-sectional regression. This serves as a robustness check of the results in Table 2. In Table 3we reports the average cross-sectional regression slopes for both equally weighted and value weighted portfolio betas assigned to individual stocks. The market model beta and the Vasicek beta estimate still maintains the negative non-significant relationship with average returns. A detailed look at panel A shows that Dimson beta is weak in explaining average returns (average slope of 0.02% but with a t-statistic of only 0.16).

Table 3: Average Time Series Slopes from Fama-French Cross-Sectional Regression in Jan. 1868-Dec. 1914

Intercept	β_{MM}	β_{dim}	β_V	t-test H_0:Slope=(R_m-R_f)
Panel A: Fama-French approach (eq)				
0.29%	-0.02%			1.40
(2.45)	**(-0.17)**			
0.24%		0.02%		0.89
(1.81)		**(0.16)**		
0.42%			-0.12%	1.03
(1.54)			**(-0.43)**	
Panel B: Fama-French approach (vw)				
0.29%	-0.02%			1.39
(2.54)	**(-0.17)**			
0.24%		0.03%		0.89
(2.04)		**(0.19)**		
0.41%			-0.12%	0.97
(1.56)			**(-0.41)**	

In this table, we assign the post-ranking portfolio beta to the individual stocks in the portfolio. Portfolios are rebalanced annually. Mean slope and their corresponding t-statistic is reported in parenthesis. We also report the t-statistic for the test of hypothesis of the mean slope equal to the average excess market returns. β_{MM}=Market Model beta, β_V=Vasicek beta and β_{dim}= Dimson beta with one lag. eq=equally weighted vw=value weighted. Newey- West adjusted t-statistics are parenthesis.

Figure 2: Sixty Months Moving Average of the Cross-Sectional Slopes and Excess Market Returns Using Dimson Beta Estimates



Using value weighted portfolios (Panel B) to estimate post-ranking betas does not establish the beta return relationship. This confirms the Fama and French (1992) result, who asserts that beta is flat in relationship with average returns for post 1960s USA data. Surprisingly, in all cases the hypothesis that the mean slope is equal the mean excess market return is not rejected. The positive average slope of the Dimson beta cross-sectional regressions (Table 3, Panel A) calls for a detailed look into its time series' behavior with the excess market returns. In addition, the average intercept is marginally significant, and it is close to the average risk-free rate as postulated by CAPM. To investigate the evolution of the slope coefficient and the excess market return through time, Figure 2 presents five-year moving average of the estimated slopes and excess market returns.

The graph shows that the relationship between beta and expected returns varies with time. Surprisingly, there seem to be a close correlation between the slopes and the excess market returns for much of the period except between the years (1880, 1885) and (1907, 1913).

Table 4:Sub-Period Look into Estimated Slopes and Excess Market Returns

sub-periods	Intercept	Slope	t-test H_0:Slope=Avg.(R_m-R_f)
Jan. 1868-Dec. 1893	0.15%	0.02%	0.09
(Avg. R_m-R_f=0.04%)	**(0.75)**	**(0.09)**	
Jan. 1894-Dec. 1914	0.32%	0.03%	2.04
(Avg. R_m-R_f=0.20%)	**(3.15)**	**(0.21)**	

In this table, Dimson's beta estimated from equally weighted portfolios is used in the cross-sectional regressions for the two sub-periods. Avg. =Average. Newey West t-statistic in parenthesis.

In Table 4, we report sub-period average slope and intercept from the Fama and French (1992) cross-sectional regressions using the Dimson beta. The last column shows the t-statistics for the test of equality of the average slope and average excess market return. For the first sub-period, the average excess market return (0.04%) is very close to the average slope (0.02%). The null hypothesis of the equal average cannot be rejected. In contrast, the null hypothesis that the average slope equals to the average excess market returns is rejected (t-statistic of 2.04) in the second sub-period as the difference in magnitude confirms (0.03% average slope and 0.20% average excess market returns). Chan and Lakonishok (1993) document similar results with post 1920 Amex and NYSE data and caution researchers and practitioners not to rush in discarding beta. The average slope is significantly less than the average excess market return (a difference of about 0.17%).

Expected Returns, Beta and the Size Effect

This section examines the well-known size effect on the 19th century BSE. That is, the propensity for large stocks to have consequent lower returns than small stocks. Early works of Banz (1981), Reinganum (1981), (1983), Chan, Chen and Hsieh (1985) and Chan and Chen (1988) first documented the size effect in modern data. Fama and French (1992) present evidence that, size and book-to-market combine to capture the cross-sectional variation in average stock returns in the period 1963-1990. Subsequently, Fama and French (1993) build a three factor model, which uses the excess market returns, size and book-to-market factors. The finance literature uses the three-factor model as a benchmark model to measure long run abnormal returns, and for many other purposes. This shows that researchers and practitioners have accepted size as an important characteristic to explain the cross-sectional behavior of long-run stock returns. On the contrary, a recent paper by Horowitz, Loughran and Savin (2000) presents evidence against the size effect in the USA market. It conjectures the magnitude of size effect is not robust when the transaction costs and very small stocks (the removal of stocks with market capitalization less than $5million) are taken into accounts. Schwert (2003) used US monthly returns data between the year 1962 to 2002 to document that the size effect disappears after 1981. With historical data, Grossman and Shore (2006) do not find any presence of the size effect on UK data between the years 1870 to 1913. This would imply size is not a systematic risk factor. We present similar evidence on the 19th Brussels Stock Exchange covering almost the same period. Each year, we sort (univariate sort) stocks based on their size (or market capitalization) at December of the prior year and then split them into decile portfolios. The market capitalization is measured as the price of stock times shares outstanding. Again, FM breakpoint method is employed to group the stocks into decile portfolios.

As in the previous sections, the smallest size stocks are put in decile one and the largest size stocks are put in decile ten. Portfolios are rebalanced each year to capture changes in their constituent stock market capital overtime. Monthly portfolio returns are calculated as the value and equally weighted averages of the individual stock returns within each of the ten portfolios. We compute the relative percentage size of a portfolio as the time series average of the cross-sectional sum of the market size of the stocks in the portfolio divided by the sum of the size of stocks in our sample. That is, if n_t is the number of stocks in a portfolio for the month t, N_t is the number of stocks in the cross-section of our sample for the month t. T is the number of years.

Table 5: Beta Estimate and Mean Excess Return for the BSE Equally Weighted Size Portfolios, Jan. 1868-Dec. 1913

		R_p-R_f		EW		VW		Standard Deviation	
Size Portfolio	**% Market Size**	**EW(%)**	**VW(%)**	β_{MM}	β_{dim}	β_{MM}	β_{dim}	**EW(%)**	**VW(%)**
1	0.35	1.12	0.01	1.61	1.89	1.43	1.56	6.16	5.26
2	0.94	0.29	0.14	1.37	1.45	1.26	1.42	4.45	3.86
3	1.60	0.10	0.10	1.16	1.30	1.16	1.28	3.43	3.37
4	2.43	0.14	0.16	1.43	1.54	1.41	1.52	3.65	3.57
5	3.56	-0.06	0.01	1.09	1.16	1.10	1.16	2.77	2.73
6	5.02	0.38	0.52	1.43	1.46	1.61	1.67	3.93	5.16
7	7.04	0.12	0.10	1.16	1.17	1.16	1.17	2.71	2.67
8	10.06	0.20	0.21	1.35	1.36	1.35	1.38	2.97	2.91
9	15.56	0.16	0.19	1.12	1.13	1.12	1.13	2.45	2.43
10	53.46	0.17	0.15	0.88	0.84	0.79	0.74	1.84	1.68
mean of hedge portfolio (%)		-0.95	0.14						
t-statsitics		**(-3.74)**	**(0.63)**						
F-statistics with the first decile		4.04							
F-statistics without the first decile		0.79							

In this table, stocks are ranked each year based on their size at the end of the prior year. They are then grouped deciles for portfolio formation. Portfolio one contains the smallest size stocks, portfolios ten contains the largest size stocks. Portfolios are rebalancec each year.Average excess returns of the decile portflios are reported in column 3 and 4. Relative market size is reported in column 2. We also report the Dimson and market model betas for the decile portfolios. We also retport the standard deviation of the portfolio return series. The Fstatistic for the test of hypothesis of equal mean of the porftolio returns is also reported.We test the hypothesis with and without the 1st decile portfolio. EW=equallyweighted and VW=value weighted.

The relative percentage of markets size is computed as:

$$\text{\% Market Size} = \frac{1}{T}\sum_{t=1}^{T}\frac{\sum_{i=1}^{n_t} Size_{it}}{\sum_{j=1}^{N_t} Size_{jt}} \times 100 \, ,$$

Two beta estimates of the size portfolios are calculated using the market model and the Dimson's model above. Table 5 reports the beta estimates and the average excess returns of the ten size portfolios during the period 1868 to 1914.It is well known in empirical finance that small stocks have both a higher beta and average return than large stocks. However, this is not the case when size portfolios are value weighted in our sample. Column 3 reveals that equally weighted portfolio 1 has an extreme average excess return (1.12%) which is almost three times the next largest excess return (0.38% from portfolio 6). The negative relation between size and returns is concentrated in the first portfolio as average excess returns sharply drops from portfolio 1 to portfolio 2. This can be confirmed from the F-statistic. The null hypothesis of equal average returns is rejected at the 1% significant level when the first decile is included in the test. Excluding the first decile portfolio fails to reject the hypothesis. In addition, the effect disappears when stocks are value weighted in the portfolios. The average excess return of the equally weighted hedge portfolio (mean excess return of -0.95% and t-statistic -3.74) shows that the size effect exists in our data.

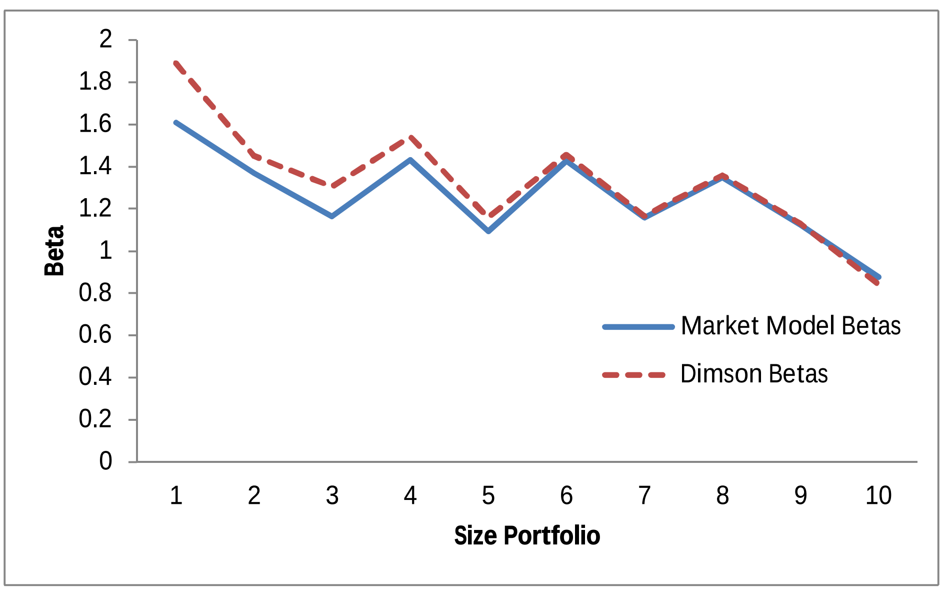
Surprisingly, the value increases to 0.14% (t-statistic of 0.63) for the value weighted hedge portfolio. Recently, Fama and French (2008) used USA data from 1963 to 2004 to document that the size effect owes much of its power to micro caps, and that it is marginal for small and big caps. As mentioned earlier on, Grossman and Shore (2006) found similar results on the UK market in the same period of our study. For robustness, we eliminate the stocks in the first size decile each year and perform the size sorting analysis. As shown in Table 6 the size effect disappears when we eliminate the first decile portfolio (portfolio with relative market size of about 0.35%) before the size portfolio formation every year.

Table 6: Equally Weighted Portfolios Excess Returns Without the First Size Decile Group

Size Portfolio	R_p-R_f(EW%)
1	0.28
2	0.10
3	0.11
4	-0.05
5	0.39
6	0.12
7	0.17
8	0.21
9	0.19
10	0.14
mean of hedge portfolio	-0.14
t-statsitic	(-0.80)

This corroborates Horowitz et al. (2000), who find no size effect in the period 1963 through to 1981 when they eliminate firms with less than five million market value on the USA market. Figure 3 plots the market model (β_{MM}) and the Dimson(β_{dim}) betas with the one-month lag for each equally weighted size portfolio. Clearly, the difference between the β_{MM} and β_{dim} progressively gets smaller as stock size gets larger. This shows that, small stock betas are underestimated when estimated with the market model. This might be due to non-synchronous trading as chapter two reveals that some stocks show lead or lag relationship with the market returns. Ibbotson et al. (1997) find similar results on the USA market between the years 1926 and 1994. They recommend the inclusion of lagged information of market returns in the estimation of beta. We also recommend the use of Dimson beta with the one-month lag when estimating betas for small stocks in our sample.

Figure 3: Size Portfolio Betas



This is to curb the possible underestimation of small stock beta. There is a clear negative correlation (-0.79 with a p-value of 0.0065) between size and portfolio beta (Figure 3).

Fama-MacBeth Cross-sectional Regressions to test the Size Effect

In order to support the above evidence on size effect, we resort to the FM cross-sectional regression method adopted by Ibbotson et al. (1997). We regress the cross-section of excess returns for a given month on the beta estimate (full window beta estimate) and natural logarithm of size by using an extended equation:

$$R_t - R_{ft} = \gamma_{0t} + \gamma_{1t}\beta_t + \gamma_{2t}\ln\left(\text{Size}\right)_{t-1} + \eta_t \qquad (0.5)$$

where γ_{0t}, γ_{1t} and γ_{2t} are the regression intercept and slopes for month t respectively. β_t is the full period estimate of beta for portfolio. In our sample, the previous section reveals that size is cross-sectionally correlated with beta. In addition, Chan and Chen (1988) argue that as size serves as a proxy for betas, they expect the betas of size portfolios to be strongly correlated cross-sectionally with size. However, when both characteristics are included in a regression, the correlation will increase the standard errors of the estimates, and this will make the outcomes murky to interpret. Fama and French (1992) show that when portfolios are formed on size alone, there is evidence of positive relationship between average return and beta (CAPM). The correlation between size and beta makes the test on size portfolios unable to disentangle the effect of size and betas on average returns. We show that when equally weighted portfolios are built on size alone, there is support for CAPM. However, allowing the variations in beta that is unrelated to size, it breaks the correlation effect of size and beta even on equally weighted portfolio excess returns. We achieve this by conditional double characteristics sorting. Specifically, we first sort stocks based on size and then sort within each size group on pre-ranking beta. We find a strong relation between size and average excess return but no relation between beta and average return for equally weighted portfolios. The size effect disappears when stocks are value weighted in portfolios. The size effect does not exist when we eliminate the first size decile portfolio in the analysis each year.

As in the sorting method, we form decile size portfolios. This is to confirm the effect of the correlation between size and beta on the beta-return relationship. To separate the correlation effect, we sort stocks into three size groups each year. Each size group is then sorted into five groups based on their pre-ranking β_{MM} or β_{dim} beta estimates. The equally and value weighted return for each portfolio is computed for each month of the following year. The conditional double sorting portfolio formation is repeated at the end of each year. The procedure generates fifteen size-beta portfolios for each beta estimate. For all portfolio formations, we use the FM breakpoint technique. Post-ranking betas are estimated with post-ranking returns over the entire period from 1868 through to 1914. Each month, we regress portfolio excess returns on beta and the natural log of size by using equation 1.5 above. The full period post-ranking betas are used in the cross-sectional regressions. Size is determined at the end of the year before the portfolio formation year.

Table 7 reports the time series averages of the slopes and intercept of the regression. The time series standard deviations of the slopes and the intercepts and are used to test whether the average is significantly different from zero. We use Newey and West (1987)heteroskedastic autocorrelation corrected standard errors for the computation of the t-statistics (reported in parentheses). The values in Panel A1 show that, the CAPM is valid for equally weighted univariate size-sorted portfolios. Both β_{MM} and $\beta_{\mathrm{d}im}$ are positively related to excess return when placed alone in the cross-sectional regression. Size is negatively related to excess returns. When size and any of the beta estimates are placed simultaneously as independent variables, only the beta estimate is significantly related to excess returns. Interestingly, size is sometimes positively insignificantly related to excess returns when placed simultaneously with beta in the regressions. This is contrary to the Ibbotson et al. (1997) result, where size is significant when placed together with market model betas in the regression.

When equally weighted portfolios are formed on size alone, both the market model and the Dimson beta with the one-month lag can predict returns at the expense of size. The relationship between beta and return disappears when stocks are value weighted in portfolio formations (Panel A2). Panels B1 and C1 show the cross-sectional regression slope and intercept for conditional double-sorted size-β_{MM} and size-β_{dim} portfolios respectively. Both betasare no more significantly related to returns, whether placed alone or with size in the regressions. Size is statistically significantly related to excess returns, whether placed alone or with any of the beta estimates. This is in support of Fama and French (1992) evidence that, the conditional double sort portfolio (size-beta sort) allows variations in beta that is unrelated to size, andwould break the correlation between size and beta.

Table 7: Average Time Series Slopes and Intercept from the Fama-MacBeth Cross-Sectional regression: Jan 1868-Dec. 1913

EQUALLY WEIGHTED				VALUE WEIGHTED			
Intercept	β_{MM}	β_{dim}	ln (Size)	Intercept	β_{MM}	β_{dim}	ln (Size)
Panel A1: Size Portfolios				**Panel A2: Size Portfolios**			
-1.06%	1.05%			-0.23%	0.31%		
(-3.62)	**(3.46)**			**(-0.83)**	**(1.12)**		
-0.88%		0.86%		-0.10%		0.20%	
(-3.50)		**(3.43)**		**(-0.45)**		**(0.86)**	
2.12%			-0.13%	-0.34%			0.03%
(2.56)			**(-2.63)**	**(-0.47)**			**(0.79)**
-0.42%	0.85%		-0.03%	-2.00%	0.62%		0.09%
(-0.40)	**(2.87)**		**(-0.55)**	**(-1.72)**	**(1.74)**		**(1.71)**
-2.05%		1.08%	0.06%	-2.45%		0.62%	0.12%
(-1.72)		**(3.50)**	**(0.97)**	**(-1.81)**		**(1.76)**	**(1.86)**
Panel B1: Size-β_{mm} Portfolios				**Panel B2: Size-β_{mm} Portfolios**			
0.26%	0.01%			0.29%	-0.12%		
(2.18)	**(0.09)**			**(2.72)**	**(-0.91)**		
1.63%			-0.09%	-0.36%			0.03%
(2.08)			**(-2.05)**	**(-0.56)**			**(0.91)**
1.69%	-0.03%		-0.09%	-0.03%	-0.12%		0.02%
(2.35)	**(-0.20)**		**(-2.18)**	**(-0.05)**	**(-0.89)**		**(0.61)**
Panel C1: Size-β_{dim} Portfolios				**Panel C2: Size-β_{dim} Portfolios**			
0.17%		0.08%		0.27%		-0.09%	
(1.35)		**(0.56)**		**(2.51)**		**(-0.67)**	
1.69%			-0.10%	-0.22%			0.02%
(2.09)			**(-2.06)**	**(-0.32)**			**(0.63)**
1.64%		0.01%	-0.09%	0.10%		-0.09%	0.01%
(2.17)		**(0.07)**	**(-2.10)**	**(0.15)**		**(-0.64)**	**(0.31)**

Each year, we sort stocks into ten portfolios based on their size at the end of the prior year. Equally and value weighted portfolio returns are computed each month in the year. The joint effect of size and beta is seperated by first forming three size portfolios and splitting each size group into five beta groups. This will yield 15 size-beta eqally and value weighted portfolios. In all portfolio formations we use the FM break point. Estimate post-ranking betas by using the full period post-ranking excess returns. Post ranking betas are used in the cross-sectional regression. t-statistics are in parenthesis.

Therefore, size will be related to average returns but beta will not. Most interestingly, when the value weighted portfolios are used in the analysis, be it univariate size sorting or conditional double size-beta sorting, beta or size is not significantly related to the average excess return (See Table 7, Panels A2, B2 and C2). This suggests that the result from the equally weighted portfolio is due to the influence of small stocks since it assigns equal weights to all stocks in portfolio formations and in the cross-sectional regressions. This confirms the sorting result in Table 5; size effect does not exist when stocks are value weighted in portfolios. We repeat the above analysis by adopting the Fama and French (1992) method. At the end of each year, the post-ranking betas estimated with the full period post-ranking returns will be assigned to each stock in the portfolio. Assigning full period post-ranking betas to stocks do not mean a stock's beta is constant, as stocks can move across portfolios with yearly rebalancing. The method uses the information available for individual stocks in the cross section. Table 8 report the average slopes and intercepts of the cross-sectional regressions using equally and value weighted portfolios to estimate the post ranking betas.

The values in parentheses are the Newey West adjusted t-statistics for the test of a hypothesis of the average slope or intercept significantly different from zero.

Table 8: Average Time Series Slopes and Intercepts from the Fama-French Cross-Sectional Regressions: Jan. 1868-Dec. 1913

EQUALLY WEIGHTED				VALUE WEIGHTED			
Intercept	**β_{mm}**	**β_{dim}**	**ln (Size)**	**Intercept**	**β_{mm}**	**β_{dim}**	**ln (Size)**
Panel A1: Size Portfolios				**Panel A2: Size Portfolios**			
-1,05%	1,04%			-0,54%	0,65%		
(-3,58)	**(3,44)**			**(-2,57)**	**(2,79)**		
-0,87%		0,85%		-0,48%		0,58%	
(-3,46)		**(3,42)**		**(-2,58)**		**(2,76)**	
2,63%			-0,16%	2,63%			-0,16%
(3,15)			**(-3,29)**	**(3,15)**			**(-3,29)**
1,51%	0,37%		-0,12%	2,43%	0,06%		-0,15%
(1,34)	**(1,22)**		**(-2,07)**	**(2,44)**	**(0,26)**		**(-2,88)**
1,16%		0,38%	-0,10%	2,86%		-0,10%	-0,17%
(0,86)		**(1,20)**	**(-1,43)**	**(2,62)**		**(-0,46)**	**(-2,91)**
Panel B1: Size-β_{mm} Portfolios				**Panel B2: Size-β_{mm} Portfolios**			
0,31%	-0,03%			0,26%	0,00%		
(2,53)	**(-0,27)**			**(2,27)**	**(0,03)**		
2,63%			-0,16%	2,63%			-0,16%
(3,15)			**(-3,29)**	**(3,15)**			**(-3,29)**
2,70%	-0,07%		-0,16%	2,77%	-0,07%		-0,16%
(3,54)	**(-0,59)**		**(-3,39)**	**(3,57)**	**(-0,50)**		**(-3,48)**
Panel C1: Size-β_{dim} Portfolios				**Panel C2: Size-β_{dim} Portfolios**			
0,21%		0,04%		0,17%		0,08%	
(1,58)		**(0,28)**		**(1,44)**		**(0,54)**	
2,63%			-0,16%	2,63%			-0,16%
(3,15)			**(-3,29)**	**(3,15)**			**(-3,29)**
2,69%		-0,05%	-0,16%	2,78%		-0,05%	-0,16%
(3,52)		**(-0,35)**	**(-3,47)**	**(3,55)**		**(-0,37)**	**(-3,55)**

Each year, we sort stocks into ten portfolios based on their size at the end of the prior year. Equally and value weighted portfolio returns are computed each month in the year. The joint effect of size and beta is seperated by first forming three size portfolios and splitting each size group into five beta groups. This will yield 15 size-beta eqally and value weighted portfolios. In all portfolio formations we use the FM break point. Estimate post-ranking betas by using the full period post-ranking excess returns. We assign post-ranking betas to the constituent stocks in the portfolio. Portfolios are rebalanced each year. t-statis-tics are in parenthesis.

From Panel A1, when the full period equally weighted portfolio returns used to estimate post-ranking betas is formed on size alone, both β_{MM} and β_{dim} have a strong relation with returns when placed alone in the regression. They lose their relationship when placed together with size in the regression. This indicates that beta, which is correlated with size serves as a proxy for size when placed alone in the regression.

Table 9: Average Time Series Slopes and Intercepts from the Fama-French Cross-Sectional Regressions without the first size decile: Jan. 1868-Dec.1913

EQUALLY WEIGHTED				VALUE WEIGHTED			
Intercept	β_{mm}	β_{dim}	ln (Size)	Intercept	β_{mm}	β_{dim}	ln (Size)
Panel A1: Size Portfolios				**Panel A2: Size Portfolios**			
-0.21%	0.31%			-0.17%	0.28%		
(-0.92)	**(1.25)**			**(-0.85)**	**(1.37)**		
-0.10%		0.21%		-0.11%		0.22%	
(-0.50)		**(0.98)**		**(-0.65)**		**(1.24)**	
0.20%			0.00%	0.20%			0.00%
(0.28)			**(-0.07)**	**(0.28)**			**(-0.07)**
-1.39%	0.54%		0.06%	-0.88%	0.37%		0.04%
(-1.27)	**(1.83)**		**(1.09)**	**(-0.89)**	**(1.55)**		**(0.77)**
-1.65%		0.51%	0.08%	-1.22%		0.37%	0.06%
(-1.30)		**(1.67)**	**(1.22)**	**(-1.10)**		**(1.61)**	**(1.05)**
Panel B1: Size-β_{mm} Portfolios				**Panel B2: Size-β_{mm} Portfolios**			
0.28%	-0.09%			0.28%	-0.10%		
(2.70)	**(-0.74)**			**(2.82)**	**(-0.72)**		
0.20%			0.00%	0.20%			0.00%
(0.27)			**(-0.06)**	**(0.27)**			**(-0.06)**
0.34%	-0.10%		0.00%	0.52%	-0.10%		-0.02%
(0.55)	**(-0.79)**		**(-0.10)**	**(0.86)**	**(-0.76)**		**(-0.41)**
Panel C1: Size-β_{dim} Portfolios				**Panel C2: Size-β_{dim} Portfolios**			
0.28%		-0.08%		0.27%		-0.08%	
(2.57)		**(-0.62)**		**(2.73)**		**(-0.60)**	
0.20%			0.00%	0.20%			0.00%
(0.27)			**(-0.06)**	**(0.27)**			**(-0.06)**
0.41%		-0.09%	-0.01%	0.55%		-0.09%	-0.02%
(0.68)		**(-0.67)**	**(-0.22)**	**(0.91)**		**(-0.67)**	**(-0.49)**

Each year, we sort stocks into ten portfolios based on their size at the end of the prior year. Equally and value weighted portfolio returns are computed each month in the year. The joint effect of size and beta is seperated by first forming three size portfolios and splitting each size group into five beta groups. This will yield 15 size-beta eqally and value weighted portfolios. In all portfolio formations we use the FM break point. Estimate post-ranking betas by using the full period post-ranking excess returns. We assign post-ranking betas to the constituent stocks in the portfolio. Portfolios are rebalanced each year. t-statistics are in parenthesis.

From Panels B1 and C1, conditional double sorting returns based on size and betas break the hold up between size and beta. It can be seen that beta has no relationship with excess return when it is placed alone or together with size. The result is similar when value weighted post-ranking returns are used to estimate post-ranking betas (See Panels A2, B2 and C2). For robustness, we repeat the Fama and French (1992) cross-sectional analysis, but excluding stocks in the first size decile each year. As in the sorting method, Table 9 does not show the significant relationship between betas and expected returns when placed alone or combine with size for single sorted size portfolios in panel A1. In Panels B1 and C1, double sorting stocks to form portfolios will not establish the relationship between betas, size and returns. When value weighted portfolio returns are used in the analysis, size and beta have no relationship with return as shown in panels A2, B2 and C2. This shows that any size effect present in our data is driven by a small group of stocks with an average relative market size of about 0.35%.

Conclusion

We used sorting and cross-sectional regression method to investigate whether the CAPM model is valid in the period before World War I. We find no support for the CAPM on the 19th century BSE. Estimating beta with the market model, the Dimson and the Vasicek model does not establish the cross-sectional relationship between average returns and the beta. However, when we use equally weighted size portfolios in the cross-sectional regressions, we find the relationship between average returns and size or beta. Size is negatively significantly related to excess returns (size effect) but beta does not relate to excess returns, when placed simultanously as regressors in the cross-sectional regression. This is due to a strong correlation that exists between size and beta. We find that, conditional double sorting portfolios by size and then by beta breaks the logjam between size and beta on excess returns. As a result, the average slope of the cross-sectional regression of returns on betas becomes insignificant when placed alone in the regression or combines with size. We recommend researchers to estimate betas with the Dimson method with the one-month lag since small stocks betas are underestimated when estimated with the market model with this data. Further investigation reveals that the size-effect in our data is mainly due to small stocks with relative market size of about 0.35% of the total market size. Eliminating these small stocks destroys the relationship between excess return, beta or size. Both the sorting and the cross-sectional regression methods reveal that the size effect disappears when the value weighted portfolios are used in the regression. Finally, in as much as our data is from a stock market which is over 140 years old, the relationship between average return, size and beta are consistent with the modern stock markets. Therefore, the behavior of size and beta in relation to the average return has remained the same on the market since the 19th century.

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