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Estimation of Capital Asset Pricing Model at Different Time Scales Application to French Stock Market*

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Abstract: In this research focus is on the estimation of the Capital Asset Pricing Model (CAPM) at different time scales for French's stock market. The proposed methods makes possible to quantify the correlation between the return of a stock and its beta at different time scales. Our sample is composed of twenty six stocks that were actively traded over 2002-2005. The empirical results show that the relationship between the return of a stock and its beta becomes stronger as the scale increase, but the test of the linearity between the tow variables show that there is an important ambiguity. Therefore, the predictions of the CAPM are more relevant at a medium-term horizon in a multi-scale framework as compared to short time horizons.

Key words: CAPM, systematic risk, scaling, beta estimation

INTRODUCTION

The Capital Asset Pricing Model (CAPM) is one of the most commonly used models in asset pricing theory and practice. The CAPM, originally, proposed by Sharpe (1964) and Lintner (1965) flowing the suggestions of mean variance optimisation in Markowitz (1952), has provided a simple and compelling theory of asset market pricing for more than 20 years.

Black *et al.* (1972) and Fama and MacBeth (1973) were supportive the implications of the CAPM. That is, the average return of high beta stocks was higher than the average return of low beta stocks. The relationship was roughly linear, although the slope was too flat to support the CAPM strongly (Campbell, 2000).

Present research concentrate on the estimation of the CAPM at different time scale. The empirical results from different economies show that the relationship between the return of a stock and its beta becomes stronger as the scale increases. Therefore, the predictions of the CAPM are more relevant in a multi scale framework as compared to short time horizons. Then we look for the nature of the relationship between the excess return from the asset and the market premium. On other word, we test the linearity between these two variables.

The CAPM has been questioned by several empirical studies. The tests generally have found that the risk premium on individual assets can be explained by variables other than the estimated covariance. In particular, the own variance, firm size and the month of January seem to be variables that help to explain expected returns (Ross, 1978). On other hand, several theoretical extensions of the CAPM has been tested such that the after tax CAPM, the international CAPM and the International Asset Pricing Model (IAPM).

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Later studies focused on the impact of return interval of betas. This research points out the importance of time scale issue. Kothari and Shanken (1995) concluded that Fama and French's results hinge on using monthly rather than yearly returns. They argue that the use of annual returns to estimate beta helps to circumvent measurement problems caused by non-synchronous trading, seasonality in returns and trading frictions.

A nearly study by Fama (1980 and 1981) showed that the power of macroeconomic variables in explaining the stock prices increased with increasing time length, than Handa *et al.* (1989) provided evidence that if different beta estimates were possible for the same stock.

In the same direction, Cohen *et al.* (1986) shows that the beta were sensitive to returns intervals. Similarity, Handa *et al.* (1993) rejected the CAPM with monthly returns were used but failed to reject the CAPM, if the yearly return interval was employed. Therefore, the studies of the impact of the time scale on the beta estimation remain very important. Lynch and Zumbach (2003) similarly emphasize the importance of a multi-scale framework in the analysis of absolute price changes to accommodate the underlying heterogeneity with intraday, daily, weekly and monthly components. Therefore, a comprehensive multi-scale approach is needed to elaborate the market dynamics across time scales in which economic agents operate.

MATERIALS AND METHODS

The capital asset pricing model implies that the excess return from asset i (in excess of the risk-free asset return) should be proportional to the market premium (market return in excess of the risk-free asset return). The derivation of the CAPM equation is based upon the assumptions of risk-averse investors, frictionless markets, absence of information costs and information asymmetries, unlimited borrowing and lending at the risk-free rate and perfect divisibility and marketability of financial assets (Copeland *et al.*, 2004).

The CAPM established that the expected return on any risky satisfy the equation:

$$E(R_i) = r_f + \beta_i E(R_m - r_f) \quad (1)$$

Where:

- R_i = Return on asset i
- r_f = Risk-free rate
- R_m = The return on the market portfolio

and

$$\beta_i = \frac{\text{cov}(R_i; R_m)}{\text{var}(R_m)}$$

The market risk premium is assumed by the return $(E(R_m) - r_f)$. It represents the return over the risk-free rate required by investors to hold the market portfolio. Equation (1) can be re-written to express that the risk premium on individual asset equals its beta time the market risk premium

$$E(R_i) - r_f = \beta_i E(R_m - r_f) \quad (2)$$

In empirical finance, the usual estimator for β_i is the OLS estimate from the following regression

$$R_{it} - r_{ft} = \beta_i (R_{mt} - r_{ft}) + \varepsilon_{it}$$

Where, ε_{it} is white noise disturbance term.

Data set of present study consist of some stocks in the CAC 40 index between January 1, 2002 and December 30, 2005. The CAC 40 index is taken to be the corresponding market portfolio. The risk free rate of return is assumed to be the daily EURIBOR. The data source for individual stocks and the CAC 40 is the web page <http://finance.yahoo.com>. Stocks prices are adjusted for dividends and splits. The daily EURIBOR is taken from the base <http://www.euribor.org>. EURIBOR is the rate at which euro interbank term deposits within the euro zone are offered by one prime bank to another. The sample size is 1044 market days or roughly 4 years.

Present object is to study the relationship between excess return on each individual stock and the time scales of market portfolio. In particular, we estimate a linear regression of each stock excess return $(R_i - r_f)$ on each recomposed crystal j of the market portfolio $(R_m - r_f)^j$:

$$R_i - r_f = \alpha_i^j + \beta_i^j (R_m - r_f)^j + \epsilon_i^j = \alpha_i^j + \beta_i^j D_m^j + \epsilon_i^j \quad j=1, \dots, 6 \quad (3)$$

The daily return of each stock is calculated as the log price difference

$$R_{it} = \log P_{it} - \log P_{it-1}$$

Where:

P_{it} = The price of asset I at day t. The market return R_{mt} is taken as the log difference of the CAC 40 index:

$$R_{it} = \log C_t - \log C_{t-1}$$

Where:

P_{it} = The index value at day t.

During the sample period, the beta of each individual stock is calculated from the Eq. 3 for scales $j = 1, 2, \dots, 6$. In our analysis, the scale 1 is associated with 2-4 days, scale 2 with 4-8 day dynamics, scale 3 with 8-16 day dynamics, scale 4 with 16-32 day dynamics, scale 5 with 32-64 day dynamics, scale 6 with 64-128 day dynamics. Scale 6 is the highest one at which we can calculate the beta of each stock because the next one corresponds to 128-256 day dynamics (Approximately one year).

RESULTS AND DISCUSSION

Here, main focus is on estimating the CAPM at different time scales for this group of stocks regularly traded on the French market. For commodity and simplicity and before going on presenting the empirical results, there are some necessary notations, that will be firstly used viz.

ACCOR(1), ADIDAS(2), AGF(3), AIR(4), ALCATEL(5), AXA(6), BOUY(7), CARREFO(8), CREAM(9), CRECA(10), CREDIT(11), DANONNE(12), DEXIA(13), ESSILOR(14), LAFARGE(15), LVMH(16), MICHELIN(17), OREAL(18), PEUGEOT(19), RENAULT(20), SANOFI(21), SHEIDER(22), THOMSON(23), TOTAL(24), VINCI(25), VIOLIA(26), CAC40(27).

We also need to adopt the following unities:

Me	Med	Max	Min	Sd	Sk	Ku
E-05	E-05	E-02	E-02	E-04	E-02	1

Table 1: Descriptive statistics of excess returns

Stock	ME	Med	Max.	Min.	SD	Sk	Ku
1	10.30	0.00	4.3088	-3.7872	82.83	10.5692	5.868254
2	4.66	0.00	3.7889	-4.1734	59.16	13.0278	14.262190
3	182.40	2.69	167.9998	-4.5037	528.39	3072.8860	976.493200
4	3.53	2.81	3.2372	-4.5267	70.28	-39.0822	7.503842
5	-25.40	0.00	14.7320	-8.4424	159.44	48.3105	14.678930
6	5.29	0.00	6.8510	-5.2807	118.81	29.0213	7.571682
7	9.67	0.00	5.0129	-4.2281	84.59	20.4317	7.954532
8	-12.90	0.00	4.1284	-4.0978	81.55	-2.2299	7.135869
9	37.50	0.00	6.4516	-2.1096	61.31	243.4775	23.134330
10	1.66	0.00	2.0251	-2.1182	31.11	-58.4745	14.336260
11	19.90	0.00	4.4759	-4.5265	80.98	-7.5536	7.278254
12	14.90	0.00	4.2130	-3.3964	54.72	71.7564	10.366690
13	14.70	2.42	5.0513	-5.2159	90.08	17.5036	8.986986
14	30.00	0.00	4.0725	-3.2003	70.30	54.8437	8.028685
15	-8.51	0.00	4.0114	-3.9068	83.02	2.1905	6.791183
16	35.80	1.65	4.8076	-3.0158	82.57	46.4284	5.962225
17	28.10	13.00	5.0287	-3.7914	84.70	43.9714	7.848305
18	-9.32	0.00	3.5371	-3.3368	71.00	-0.8637	6.258607
19	28.20	22.60	5.1291	-5.2159	92.52	25.9182	8.854354
20	39.30	0.00	3.8096	-3.7589	86.60	6.0331	5.550694
21	10.20	0.00	3.9386	-4.4209	83.09	-3.7673	6.098279
22	31.20	11.70	2.9089	-3.8693	74.73	2.8376	5.775753
23	-12.40	-2.51	6.0026	-8.6215	116.45	-24.3081	8.617440
24	44.90	36.80	5.1703	-3.5322	73.72	55.2349	9.108402
25	84.30	3.16	30.3496	-3.3261	112.39	1873.0830	505.194400
26	16.70	0.00	6.4451	-5.3646	91.46	52.6223	10.913050
27	0.25	8.20	3.0411	-2.6252	63.52	6.9982	6.722768

Table 1 presents descriptive statistics of excess returns on the 26 stocks in the sample and on the proxy for the market portfolio, the CAC 40. The latter gathers the forty most actively-traded stocks on the French market over the past year.

Figure 1 shows that, as is the case with most financial assets, excess return on the stocks and the market portfolio exhibit little skewness but high kurtosis. It shows the recomposed crystals D_1 and D_6 of the excess return on the market portfolio at scale 1 and 6, respectively. D_1 depicts the high frequency movements of the market portfolio, whereas D_6 depicts its long-term behaviour.

Table 2 reports the OLS estimate of the regression coefficient of each stock excess return (dependant variable) versus each recomposed crystal j of the market portfolio (independent variable) versus each recomposed crystal j of the market portfolio (independent variable).

Table 3 shows that the relationship between the two variables is positive and significant at all scales. When looking at individual excess return, the mean contribution of D_m^j , generally, tends to decline as the scale increases and its explanatory power measured by R^2 increases with the scale. This implies that the major part of the market portfolio's influence on individual stocks is at the higher frequencies.

An alternative way of analysing the same issue is by regressing Eq. 3 and by changing time scales, so that scale1 will be associated with 3-6 days, scale 2 with 6-12 day dynamics, scale 3 with 12-24 day dynamics, scale 4 with 24-48 day dynamics, scale 5 with 48-96 day dynamics, scale 6 with 96-192 day dynamics. We limited at the scale 6 for the same reasons advanced above. The change of the width of the scale allows us the possibility to quantify the relation between excess return on each individual stock and the time scales of market portfolio at others scales too large as compared to scales utilized. Unlike the results reported in Table 2 and 3.

Table 4 shows that the mean contribution of D_m^j is concentrated at the lower frequencies. On other word, the relationship between excess return and the market portfolio becomes, in general, stronger at the higher scales of two variables (Table 5). Similar conclusions are drawn by Viviana (2005) for a sample of 24 stocks traded on the Santiago Stock Exchange.

Table 2: Beta for scales 1, 2, ...,6 (Dyadic scales)

Stock	D ₁	D ₂	D ₃	D ₄	D ₅	D ₆
1	0.595223	0.704657	0.804514	0.777651	0.389108	0.457059
2	0.517236	0.491507	0.516123	0.523778	0.409725	0.354019
3	0.112432	1.292078	1.308902	1.279752	0.675003	0.728871
4	0.856347	0.833128	0.774147	0.757677	0.369497	0.337392
5	1.561706	1.623021	1.732203	1.745769	1.199334	1.435544
6	1.681537	1.623330	1.605993	1.603601	0.734408	0.744551
7	0.931858	0.979499	1.029685	0.932630	0.480314	0.448354
8	1.012157	1.012219	0.514843	0.736264	0.406232	0.407055
9	0.152291	0.202713	0.204409159	0.201239	0.170497	0.189116
10	0.067631	0.097964	0.204409	0.268319	0.170497	0.191219
11	0.738384	0.786315	0.894778	0.851313	0.223727	0.383565
12	0.560473	0.553309	0.604217832	0.704093	0.363321	0.304425
13	1.134155	1.066464	1.088986	1.097390	0.612994	0.648437
14	0.381420	0.413097	0.377492	0.434320	0.257400	0.159240
15	0.857956	1.001504	1.038485	0.680822	0.274880	0.264387
16	0.995476	1.010280	0.974783	0.971949	0.554625	0.508663
17	0.838411	0.915326	0.915627	1.049828	0.514958	0.498356
18	0.814033	0.766842	0.733137	0.735028	0.339536	0.250063
19	1.134155	1.066464	1.088986	1.097490	0.612995	0.648396
20	0.953069	1.066898	1.018910	1.067093	0.464904	0.462599
21	0.890394	0.825398	0.760470	0.767023	0.402553	0.302018
22	0.663203	0.796107	0.866808	1.074537	0.373027	0.310664
23	-0.179716	1.428617	1.445518	0.936255	0.492558	0.554479
24	-0.012481	0.774218	0.788343	0.886783	0.450478	0.402736
25	-0.032856	0.468897	0.456304	0.459472	0.376511	0.377691
26	-0.077343	0.872982	0.762189	0.795089	0.402442	0.545849
SD	6.096805	1.471787	3.529331	1.284633	3.678361	0.958707
Me	0.659505808	0.872032077	0.865779307	0.862890962	0.450827846	0.458259538

Table 3: R² for scales 1, 2, ...,6 (Dyadic scales)

Stock	D ₁	D ₂	D ₃	D ₄	D ₅	D ₆
1	0.205047	0.306547	0.382347	0.433355	0.446644	0.747443
2	0.288121	0.296967	0.400785	0.387849	0.640905	0.611731
3	0.112432	0.682956	0.712314	0.624330	0.636411	0.794197
4	0.614371	0.601329	0.612967	0.603408	0.602493	0.760396
5	0.441733	0.395706	0.399854	0.334133	0.491362	0.697415
6	0.755526	0.802908	0.814135	0.751818	0.704265	0.804959
7	0.486832	0.979499	0.556843	0.488179	0.515318	0.659539
8	0.656679	0.656077	0.556843	0.326186	0.333739	0.590851
9	0.028169	0.047411	0.045775011	0.036641	0.076284	0.143047
10	0.014656	0.024494	0.045775	0.143290	0.076284	0.270586
11	0.393045	0.418445	0.508196	0.420528	0.260830	0.497880
12	0.376404	0.422510	0.472470542	0.490552	0.318722	0.501190
13	0.565886	0.608091	0.629581	0.574081	0.682725	0.778005
14	0.130478	0.163220	0.154948	0.189097	0.274736	0.305422
15	0.498113	0.570205	0.609224	0.373300	0.236380	0.332550
16	0.578971	0.532337	0.510760	0.462081	0.429105	0.412653
17	0.615506	0.629549	0.556580	0.534326	0.670162	0.742278
18	0.439541	0.502271	0.469108	0.491343	0.430964	0.614354
19	0.565886	0.608091	0.629581	0.574131	0.682773	0.777934
20	0.503886	0.560786	0.588507	0.506843	0.372024	0.393511
21	0.482773	0.441082	0.453034	0.356040	0.364658	0.438156
22	0.353866	0.465281	0.525826	0.615021	0.474180	0.616317
23	0.010354	0.532403	0.509274	0.266855	0.351064	0.525469
24	0.000128	0.516756	0.516279	0.499920	0.505628	0.636284
25	0.000360	0.070540	0.066689	0.048499	0.110438	0.162880
26	0.002453	0.309889	0.398878	0.340185	0.306535	0.705510
SD	3.131796	0.782764	1.088736	0.888495	1.631000	0.988514
Me	0.350816	0.467128846	0.466406675	0.4181535	0.422870346	0.558482962

Table 4: Beta for scales 1, 2, ...,6 (Triadic scales)

Stock	D ₁	D ₂	D ₃	D ₄	D ₅	D ₆
1	0.215955	0.855922	0.508699	0.818244671	1.028608	0.918514
2	0.283360	0.475281	0.508699	0.553214	0.637601	0.502436
3	0.567976	1.373897	1.409066	1.413430	1.408419	1.471768
4	0.336888	0.869325	0.766339	0.707912	0.681108	0.794685
5	0.854510	1.702730	1.899157	1.875413	2.286837	2.896155
6	0.761880	1.624599	1.608905	1.628824	1.567547	1.483165
7	0.761880	0.967476	1.026656	0.932298	1.029609	0.819479
8	0.761880	0.977075	0.904195	0.849166	0.760116	0.732341
9	0.060434	0.211700	0.275148	0.210310	0.177794	0.242327
10	0.082285	0.242517	0.360970	0.348709	0.177794	0.577055
11	0.472268	1.113897	0.360970	1.339056	1.053665	1.258715
12	0.470124	0.898456	1.038112	1.024368	0.973892	1.002707
13	0.508533	1.122818	1.140887	1.188236	1.216409	1.241403
14	0.142170	0.442014	0.502394	0.485147	0.649981	0.476297
15	0.337794	0.963726	0.849598	0.753307	0.649981	0.592905
16	0.471048	0.988433	1.036463	0.912876	1.046754	1.029978
17	0.303106	0.908273	0.969160	0.866780	0.868764	0.871825
18	0.318489	0.823436	0.770697	0.780728	0.565118	0.505908
19	0.508533	1.122818	1.140887	1.188236	1.216409	1.241403
20	0.486280	0.941711	1.072593	1.077212	1.059354	0.689041
21	0.352418	0.802362	0.695772	0.724324	0.680224	0.713195
22	0.380830	0.861507	0.917366	0.891393	0.787181	0.621234
23	0.666060	1.235108	1.308813	0.955670	0.985560	0.925484
24	0.352265	0.763501	0.785934	0.804761	0.830591	0.784861
25	0.286352	0.543702	0.567609	0.450433	0.634923	0.755773
26	0.440017	0.862547	0.840182	0.853935	0.995739	0.982662
SD	1.094559	0.044476	3.135107	0.970591	3.772899	0.912482
Me	0.43012827	0.91133965	0.89481812	0.90899933	0.92192223	0.92812754

Table 5: R² for scales 1, 2, ...,6 (Triadic scales)

Stock	D ₁	D ₂	D ₃	D ₄	D ₅	D ₆
Accor	0.027777	0.388795	0.322544	0.527215063	0.772184	0.820206
Adidas	0.098879	0.324778	0.322544	0.506225	0.497327	0.330605
Agf	0.139770	0.705404	0.720976	0.788347	0.826412	0.908880
Air	0.110213	0.691257	0.611253	0.756661	0.727632	0.840112
Alcatel	0.113797	0.420619	0.378756	0.432439	0.532059	0.682883
Axa	0.160486	0.779125	0.772443	0.809167	0.800859	0.912707
Bouy	0.098879	0.491080	0.530226	0.659352	0.741584	0.781144
Carrefo	0.121937	0.593689	0.457876	0.539072	0.635925	0.622915
Cream	0.004979	0.211700	0.073820	0.054547	0.042031	0.081695
Creca	0.008163	0.050978	0.114253	0.161408	0.042031	0.421128
Credit	0.067357	0.069699	0.114253	0.584289	0.453630	0.622557
Danonne	0.125893	0.459952	0.566750	0.624519	0.539437	0.693999
Dexia	0.122966	0.641202	0.647093	0.719160	0.794720	0.873498
Essilor	0.142170	0.215153	0.269190	0.338731	0.414121	0.382991
Lafarge	0.070043	0.570486	0.496734	0.515308	0.414121	0.441559
L'oreal	0.093005	0.565285	0.528990	0.595415	0.455042	0.463376
LVMH	0.134709	0.599376	0.579735	0.652677	0.711156	0.736284
Michelin	0.056412	0.460754	0.454655	0.541635	0.527675	0.630102
Peugeot	0.122966	0.641202	0.647093	0.719160	0.794720	0.873498
Renault	0.124599	0.506528	0.502165	0.622787	0.513583	0.435851
Sanofi	0.070635	0.413838	0.339134	0.475767	0.450478	0.529713
Sheider	0.108894	0.537963	0.525697	0.658907	0.666243	0.775441
Thomson	0.124842	0.486097	0.407641	0.453928	0.985560	0.526202
Total	0.111562	0.503308	0.464085	0.635236	0.622450	0.623172
Vinci	0.026817	0.092956	0.095468	0.074736	0.117028	0.251183
Violia	0.092453	0.335003	0.372458	0.476650	0.633555	0.718808
Std. Dev.	3.553440	0.978932	4.494739	1.392725	6.389793	1.180910
Mean	0.09539242	0.45216258	0.43522431	0.535513	0.56582935	0.61463496

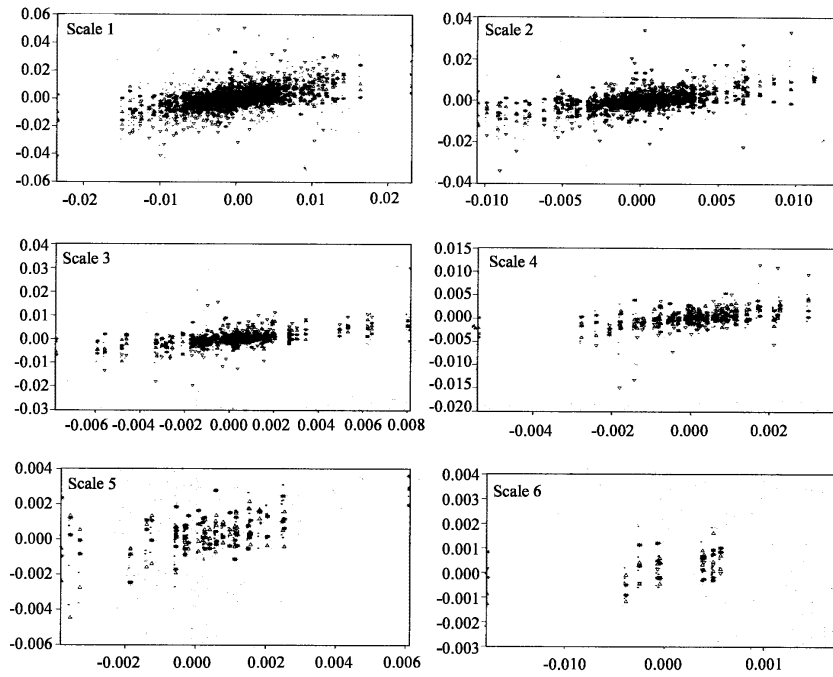


Fig. 1: Excess return on the market (horizontal axis) against excess return on the stock (vertical axis) at different scales. Scale 1: 2-4 days, scale 2: 4-8 days and so on

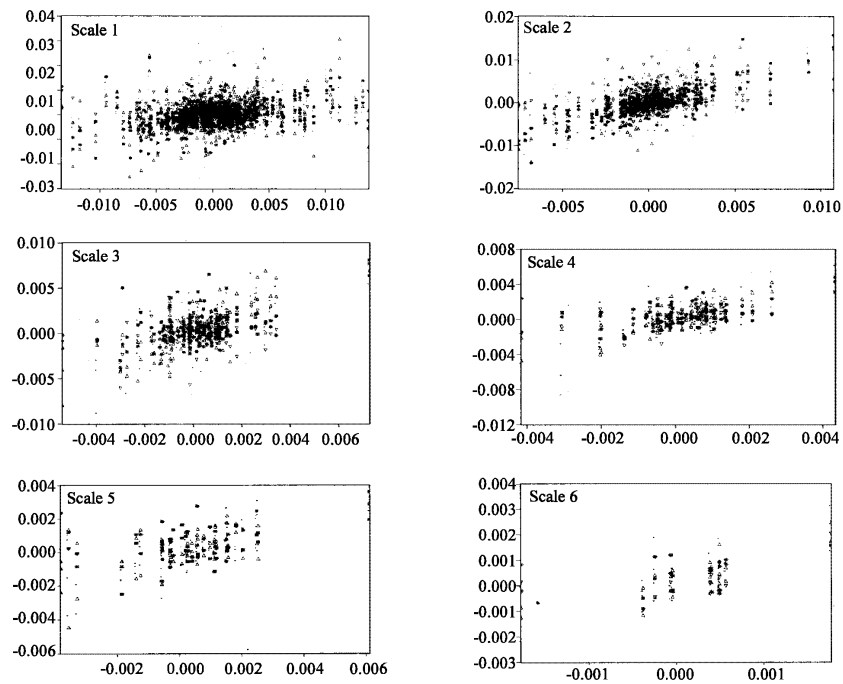


Fig. 2: Excess return on the market (horizontal axis) against excess return on the stock (vertical axis) at different scales. Scale 1: 3-6 days, scale 2: 6-12 days and so on

Figure 2 plots excess returns on stocks (vertical axis) against corresponding excess returns on market D_1 at different scales in French stock. The scales are such that 1 is associated with 2-4 days dynamics, scale 2 is associated with 4-8 days dynamics and so on. This Fig. 2 shows that the linear association between the two variables is particularly strong at scales 2 and 3. These findings enforce the fact that the relationship between each recomposed crystal of the excess return on the stock and the corresponding recomposed crystal of the market portfolio is more relevant at the mediums scales than others scales during the sample period. Similar results are drawn by Gençay *et al.* (2005, 2002). Figure 2 shows that linearity between these two variables is not clear with scales more larges (scale 1: 3-6, scale 2: 6-12 and so on). So we can not conclude about the linearity between the stock return and its beta. Theses results let us to think about other methods to estimate the capital asset pricing model.

CONCLUSIONS

In this research, main focused is on the estimation of the Capital Asset Pricing Model (CAPM) at different time scales for French stock market. Our sample is composed of twenty six stocks that were actively traded over 2002-2005. The empirical results show that the relationship between the return of a stock and its beta becomes stronger at the medium scales, but the test of the linearity between the tow variables show that there is an important ambiguity. Therefore, the predictions of the CAPM are more relevant at a medium-term horizon in a multi scale framework as compared to short time horizons. We notice also that the proposed method in this paper has shown some lack in concluding about the linearity between the return and its beta (systematic risk). This leads us to think about some more adoptable and relevant methods to enlighten the ambiguity. An extension of present study using wavelet theory has been started and it seems to give good results. Wavelets are suitable adopted mathematical tools that have been world-wise developed until the 80's. They have been shown successful applications in physics, mathematics, finance, statistics, etc. We intend in the near future to obtain good results using these mathematical tools.

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