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AN EMPIRICAL VALIDATION OF FAMA AND FRENCH THREE-FACTOR MODEL (1992, A) ON SOME US INDICES

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ABSTRACT

The study of mean returns of American stocks showed a poor β coefficient of the Sharpe (1964) and Lintner (1965) capital asset pricing model or the consumption coefficient of Breeden (1979); Reinganum (1981) and Breeden et al. (1989) international consumption-oriented capital asset pricing model. In the same line of thinking, capital asset pricing theory is efficient in explaining stocks mean returns. The empirically determined variables include size (ME: stock price multiplied by stocks number), leverage effect, equity divided by price ($^{E}/_{P}$) and the book-to-market ratio (ratio between stock book value and its market value). Banz (1981); Bhandari (1988); Basu (1983) and Rosenberg et al. (1985) have empirically determining these variables. Using the same method of Fama and French (1992a) we studied the joint roles of market β, size, $^{E}/_{P}$, leverage effect and book-to-market ratio in mean returns. They found that using alone or combined with other variables, β (the regression slope of stock return on market return) poorly explains mean returns. Combining size and market-to-book ratio, the two variables seem to absorb the apparent roles of leverage effect and the $^{E}/_{P}$ ratio in explaining mean returns. The main result is that the two empirically determined variables (size and book-to-market) explain well mean returns on the ADI, DJI, TDI and DJU during the 2000-2010 period.

Keywords: Financial markets, Stock markets, Efficiency, Asset pricing.

Contribution/ Originality

This study contributes in the existing literature by using the FF-3 model to test the efficiency of the market instead of pricing the asset.

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1. PRESENTATION OF Fama and French (1993) AND THE RESEARCH HYPOTHESES

1.1. Fama and French (1992a)

To explain market returns behaviour, Fama and French (1993) developed the Fama-French three-factor model.

Before them, the capital asset pricing model (CAPM) used a single factor to explain excess return of a stock relative to market excess return. Fama and French have then added two other factors and found two classes of stocks able to generate higher returns than those of the market (small capital and stocks with high book-to-market ratios). The model can be represented by the following multivariate regression:

$$R_{j,t} = a_j + b_j MKT_t + s_j SMB_t + h_j\, HML_t + \varepsilon_t \quad (1)$$

Where $R_{j,t}$ denotes excess return of portfolio j at month t, MKT_t is excess return of the market portfolio, SMB_t is portfolio return where stocks are classified in terms of performance and size and HML_t is portfolio return where stocks are classified in terms of performance and value.

As for coefficients $b_j, s_j\ et\ h_j$ are manifestation of market factors, size and portfolio value j, a_j is mean abnormal portfolio return j, which is zero in the original model , ε_t is error term that has a multivariate normal distribution and identically distributed over time.

1.2. Research Hypotheses

Our empirical validation of Fama-French three-factor model aims at determining the optimal configuration that allows for a better explanation of returns, especially, we should observe high values of $\overline{R^2}$ to confirm that the indices are not efficient. To this end, we will make changes in market size, then compare the explanatory power of the various estimates, on three hypotheses:

- Hypothesis 1: The explanatory power of Fama-French three-factor model increases with the increasing the size of the index (number of firms)
- Hypothesis 2: The explanatory power of Fama-French three-factor model increases with the decreasing size of index,
- Hypothesis 3: There is no relationship between the explanatory power of Fama-French three-factor model and index size.

In what follows, we will first describe data and second, we will present the methodology of constructing factors portfolio.

2. PRESENTATION OF DATA AND CONSTRUCTION OF FACTORS PORTFOLIO

2.1. Presentation of Data

We consider four indices of different sizes (number of composite stocks). We examine the different Dow Jones indices, including: ADI (Dow Jones composite average) consisting of 65 stocks, DJI (Dow Jones Industrial Average) consisting of 30 stocks, TDI (Dow Jones

Transportation Average) consisting of 20 shares and DJU (Dow Jones Utility Average) consisting of 15 stocks.

We consider monthly returns of all indices and stocks. The study period stretches from January 2000 to December 2010. Riskless rate, we consider interest rate of a three-month maturity American treasury bond. All time series of this data are extracted from Yahoo Finance.

2.2. Methodology of Factors Portfolio Construction

Like Fama and French (1992a; 1992b), we construct six portfolios for each index. First, the stocks will be sorted in an ascending order according to size criteria (market value: ME). Then, we divide equally the stocks into two parts. Second, we rank in an ascending order each sub-portfolio using the book-to-market ratio test. Then, we divide each sub-portfolio into three parts: the first represents 30%, the second 40% and the last 30%.

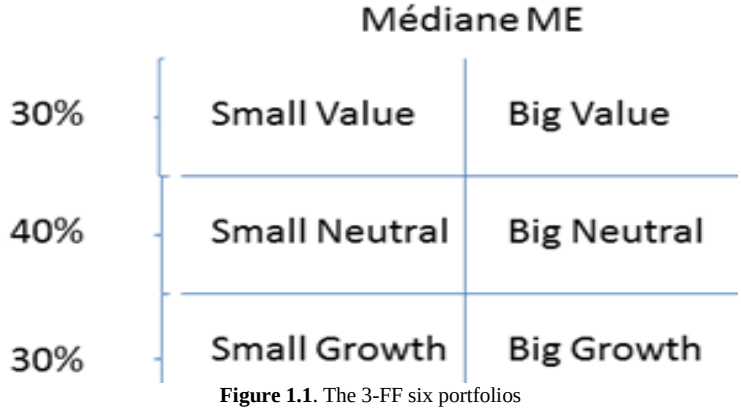

Figure 1.1. The 3-FF six portfolios

As shown in Figure (1-1), we have six value-weighted portfolios containing all the stocks in the index, namely: Small Value, Small Neutral, Small Growth, Big Value, Big Neutral and Big Growth. Next, we calculate SMB portfolio returns which are the mean return of the three small portfolios minus that of the Big portfolios:

$$SMB = {}^{1}/_{3} \times (Small\ Value + Small\ Neutral + Small\ Growth) - {}^{1}/_{3}\,(Big\ Value + Big\ Neurtral + Big\ Growth) \quad (2)$$

Likewise, HML portfolio return is the mean return of two value portfolios minus the return of the two Big portfolios:

$$HML = {}^{1}/_{2} \times (Small\ Value + Big\ Value) - {}^{1}/_{2}\,(Small\ Growth + Big\ Growth) \quad (3)$$

It should be noted that we consider this ranking throughout the study period, in contrast to Fama and French (1992a; 1992b) who have redone the rankings each year, because of unavailability of data on the evolution of stocks book value.

3. THE RESULTS AND THEIR INTERPRETATION

3.1. Time Series Descriptive Statistics

A-Descriptive statistics of the ADI index:

Table below shows the descriptive statistics of the ADI index:

Table-1. Descriptive statistics of the ADI index

Statistics	SG	SN	SV	BG	BN	BV	SMB	HML	MKT	R^2
Mean	0.00468	0.0006282	0.0024282	0.0078807	0.0047576	0.0061816	-0.003694	-0.001975	-0.007262	0.0027373
Maximum	0.2380058	0.1520698	0.1444206	0.1375494	0.1297424	0.1889321	0.0853745	0.0791091	0.0777615	0.0877615
Minimum	-0.1655	-0.159778	-0.199005	-0.148531	-0.123927	-0.136307	-0.066412	-0.141988	-0.151696	-0.141696
Skewness	0.2023901	-0.497432	-0.706718	-0.349838	-0.434378	-0.102857	0.5808828	-0.707379	-0.736498	-0.736498
Kurtosis	3.361822	3.937588	4.569464	2.856699	3.383854	4.637677	3.240363	4.388841	3.912207	3.912207
Mdian	0.0004248	0.006686	0.0101974	0.0163932	0.0094695	0.0098101	-0.009586	-0.002084	-0.003541	0.0064585
Stand. Dev	0.0700327	0.0511052	0.0559897	0.0553256	0.045479	0.0487427	0.0294306	0.0379178	0.0447596	0.0447596

Examination of the descriptive statistics of the returns of the ADI index leads us to several conclusions. The mean returns of the six elementary portfolios vary between 0.0006282 and 0.0078807. However, we found maximum values of 0.2380058 (SG portfolio) and minimum values of of -0.199005 (SV portfolio). Therefore, we found a considerable variation and a relatively high standard deviation. The SMB and HML portfolios derive from these six components. We recorded negative means because SMB return is the difference between the returns of the three Small portfolios (SG, SN and SV) and the three Big portfolios (BG, BN and BV), i.e. the difference between lower market value portfolios returns and upper market value portfolios returns.

(R) index returns are between -0.141696 and 0.0877615 with a mean of 0.0027373. MKT portfolio returns are the differences between the index returns and the three-month maturity treasury bond interest rates. Therefore, the MKT portfolio will have the same returns like those of the ADI index.

We observed negative skewness values for all elementary portfolios except SG and positive for HML, MKT and R. A negative skewness value indicates that the return distributions are concentrated on the right side of the median. SG portfolio returns distribution is right-tailed like the SMB portfolio. As for kurtosis, we recorded values higher than the normal distribution (zero). Therefore, returns distributions of these portfolios are marked by curves with thicker tails, and consequently are leptokurtic distributions.

B- Descriptive statistics for the DJI index :

The table below reports the descriptive statistics of the DJI index:

Table-2. Descriptive statistics of the DJI index

Statistics	SG	SN	SV	BG	BN	BV	SMB	HML	MKT	R^2
Mean	-0.002160	-0.002052	-0.000346	0.0014764	0.0034514	0.0057607	-0.005082	0.0030492	-0.008905	0.0010949
Maximum	0.2376395	0.1580089	0.2616202	0.269861	0.0843102	0.1712245	0.1452179	0.134063	0.0960468	0.1060468
Minimum	-0.167936	-0.145915	-0.277867	-0.174544	-0.130137	-0.179603	-0.118428	-0.177305	-0.150604	-0.140604
Skewness	0.3553924	-0.156548	-0.542770	0.6207093	-0.953522	-0.124409	0.5739578	-0.377971	-0.452230	-0.452230
Kurtosis	3.774167	3.260963	5.565438	5.833278	4.020499	3.693013	5.393422	5.566071	3.545134	3.545134
Mdian	-0.003045	0.0030969	0.0032843	-0.000051	0.0097802	0.0103451	-0.009428	0.0037272	-0.006776	0.0032235
Stand. Dev	0.0701895	0.0568539	0.080558	0.0624422	0.0439451	0.058907	0.0366694	0.0422422	0.0454679	0.0454679

As for DJI index, the means of the six elementary portfolios range from -0.002160 (FT) to 0.0057607 (BV). Mean returns of Small portfolios are negative and the same for SMB and MKT,

unlike mean returns of Big, HML and R portfolios. However, maximum values range from 0.0843102 (BN) to 0.269861 (BG) and minimum values range from -0.277867 (SV) to -0.130137 (BN). The DJI index returns vary between -0.140604 and 0.1060468.

Standard deviation of the six elementary portfolios are relatively high and vary between 0,0439451 (BN) and 0,080558 (SV). The derived portfolios SMB and HML are marked by lower standard deviation. Moreover, the R index has a standard deviation lower than all the standard deviation of the elementary portfolios (except for BN).

The skewness is negative for all portfolios except SG, BG and SMB. And as a result, most portfolios present left-skewed distribution that is to say distributions concentrated to the right of the median. The kurtosis is always greater than three. So we are always in front of leptokurtics distributions.

A- The descriptive statistics of the DJT index:

The table below reports the descriptive statistics of the DJT index.

Table-3. Descriptive statistics of the DJT index

Statistics	SG	SN	SV	BG	BN	BV	SMB	HML	MKT	R²
Mean	0.0122337	0.008537	0.0031615	0.0070884	0.0120605	0.0070576	-0.000758	-0.004551	-0.003690	0.0063096
Maximum	0.4722552	0.1714098	0.239934	0.1831792	0.173663	0.24151	0.2171439	0.1306597	0.161407	0.171407
Minimum	-0.331156	-0.230658	-0.254994	-0.186087	-0.225159	-0.269474	-0.116257	-0.231475	-0.229921	-0.219921
Skewness	0.4833855	-0.089747	0.0437476	-0.125672	-0.307234	-0.321687	1.005376	-0.371521	-0.496588	-0.496588
Kurtosis	4.960898	4.035652	3.648789	3.245976	2.940493	7.228818	4.891207	4.227263	3.749014	3.749014
Median	0.0072703	0.0064315	-0.000875	0.0097003	0.0162712	0.0082085	-0.005929	-0.004727	0.0059902	0.0159902
Stand. Dev	0.1185371	0.0643996	0.0784032	0.066133	0.0738195	0.0634752	0.0606438	0.0571333	0.0660411	0.0660411

The mean of the six elementary portfolios vary between 0,0031615 (SV) and 0,0122337 (SG). Nevertheless, the maximum values range between 0,1714098 (SN) and 0,4722552 (SG). However, the minimum values range between -0,331156 (SG) and -0,186087 (BG). We may conclude then that there are substantial variations in the study windows. Standard deviation corroborates this finding. They vary between 0,0634752 and 0,1185371. Even for the other portfolios (SMB, HML, MKT and R), we found high values. As for skeweness coefficient, the values are generally negative and therefore they are right-tailed except for SG, SV and SMB. Like DJA and DJI, DJT components are leptokurtic except the BN portfolio which is mesokurtic.

A- The Descriptive statistics of DJU index

The table below reports the descriptive statistics of the DJU index.

Table-4. The descriptive statistics of the DJU index.

Statistics	SG	SN	SV	BG	BN	BV	SMB	HML	MKT	R²
Mean	0.0074335	0.0036445	0.0003194	0.0043975	0.0071557	0.0054503	-0.001868	-0.003030	-0.006024	0.0039751
Maximum	0.3824115	0.2095457	0.222241	0.1774873	0.1504687	0.179707	0.1604905	0.1500152	0.1075838	0.1175838
Minimum	-0.456123	-0.187266	-0.348114	-0.257851	-0.198897	-0.156269	-0.159084	-0.176555	-0.143927	-0.133927
Skewness	-0.307735	0.021081	-1.104819	-0.991077	-0.838596	-0.370754	0.0929604	-0.097208	-0.510207	-0.510207
Kurtosis	6.284112	5.313689	7.459611	6.302566	4.616302	4.175761	4.659124	3.571041	3.218962	3.218962
Median	0.0146574	0.0012682	0.0105122	0.0089502	0.0165119	0.014161	0.0000405	-0.002684	0.0018558	0.0118558
Stand. Dev	0.1133595	0.0610014	0.0732644	0.0639479	0.0541111	0.0542059	0.0530276	0.058166	0.0500966	0.0500966

As for the DJU index, we found means that vary between 0,0003194 (SV) and 0,0074335 (SG) for the elementary portfolios. For the derived portfolios, the means are negative and the R index has a mean of 0,0039751. The maximum values range between 0,1504687 (BN) and 0,3824115 (SG) for the six elementary portfolios. The minimum values vary between -0,456123 (SG) and -0,156269 (BV). Like the other indices, DJU components have standard deviations that vary from 0,0541111 (BN) to 0,1133595 (SG). The variations of the other portfolios, mainly SMB, HML, MKT and R are generally lower than those of the six elementary portfolios.

Skeweness is generally negative, except for SN and SMB and then the distributions are left-skewed, i.e. concentrated to the right of the median. Kurtosis is often greater than 3 and distributions are leptokurtic.

Table-4. The descriptive statistics of the DJU index.

Statistics	SG	SN	SV	BG	BN	BV	SMB	HML	MKT	R^2
Mean	0.0074335	0.0036445	0.0003194	0.0043975	0.0071557	0.0054503	-0.001868	-0.003030	-0.006024	0.0039751
Maximum	0.3824115	0.2095457	0.222241	0.1774873	0.1504687	0.179707	0.1604905	0.1500152	0.1075838	0.1175838
Minimum	-0.456123	-0.187266	-0.348114	-0.257851	-0.198897	-0.156269	-0.159084	-0.176555	-0.143927	-0.133927
Skewness	-0.307735	0.021081	-1.104819	-0.991077	-0.838596	-0.370754	0.0929604	-0.097208	-0.510207	-0.510207
Kurtosis	6.284112	5.313689	7.459611	6.302566	4.616302	4.175761	4.659124	3.571041	3.218962	3.218962
Median	0.0146574	0.0012682	0.0105122	0.0089502	0.0165119	0.014161	0.0000405	-0.002684	0.0018558	0.0118558
Stand. Dev	0.1133595	0.0610014	0.0732644	0.0639479	0.0541111	0.0542059	0.0530276	0.058166	0.0500966	0.0500966

As for the DJU index, we found means that vary between 0,0003194 (SV) and 0,0074335 (SG) for the elementary portfolios. For the derived portfolios, the means are negative and the R index has a mean of 0,0039751. The maximum values range between 0,1504687 (BN) and 0,3824115 (SG) for the six elementary portfolios. The minimum values vary between -0,456123 (SG) and -0,156269 (BV). Like the other indices, DJU components have standard deviations that vary from 0,0541111 (BN) to 0,1133595 (SG). The variations of the other portfolios, mainly SMB, HML, MKT and R are generally lower than those of the six elementary portfolios Skeweness is generally negative, except for SN and SMB and then the distributions are left-skewed, i.e. concentrated to the right of the median. Kurtosis is often greater than 3 and distributions are leptokurtic 5-4-2- The results and their interpretations:

A- The DJA index:

The following table reports the results of regressing the model (equation 1) for the DJA index, considering the six composite portfolios as dependent variables:

Table-5. The results of the regression of the DJA index

Portfolio	SMB	HML	MKT	t(SMB)	t(HML)	t(MKT)	R^2	$\overline{R^2}$	F(3,129)
SG	0,989504	-0,858488	0,892943	11,79	-13,11	16,52	0,8434	0,8398	231,61
SN	0,545088	0,182290	0,906383	7,38	3,16	19,05	0,7712	0,7659	144,95
SV	0,559699	0,437664	1,002019	7,60	7,61	21,11	0,8106	0,8062	184,04
BG	-0,492554	-0,442509	1,022029	-6,74	-7,76	21,72	0,8128	0,8085	186,73
BN	-0,350403	-0,057362	0,866362	-5,27	-1,11	20,23	0,7684	0,7630	142,64
BV	-0,062750	0,261338	0,912953	-0,82	4,40	18,60	0,7373	0,7312	120,70
						Mean	0,7906	0,7857	

Since our study seeks to determine whether the explanatory power of the Fama-French three-factor model increases with index size, we will focus on R^2 and adjusted R^2 coefficients. However, we find that the independent variables are significant at the 5% level (|t-value|>1,96) except for the variable SMB when explaining the BV portfolio. As for the significance test of the overall model, we found that all Fisher test values (F (3.129)) are greater than 2.86. Also, the model is globally significant at the 5%. We found also an overall significance at the 1% as the Fisher test value is always greater than 3.91.

R^2 and adjusted R^2 are close to unity for the six regressions. They range from 0.7312 to 0.8434. Their means are 0.7373 and 0.7857, respectively. Therefore, the model has a high explanatory power.

B-The DJI index:

The following table reports the regression results of the model for the DJI index with the six composite portfolios as dependent variables:

Table-6. The regression results of the DJI index

Portfolio	SMB	HML	MKT	t(SMB)	t(HML)	t(MKT)	R^2	$\overline{R^2}$	F(3,129)
SG	-0,7486492	-0,6033621	1,009609	11,21	-10,70	18,88	0,8525	0,8491	248,59
SN	0,4233305	-0,1094813	0,9266379	6,10	-1,87	16,69	0,7577	0,7521	134,49
SV	0,6635722	0,8412236	1,096043	7,80	11,72	16,11	0,8185	0,8143	193,94
BG	-0,3948517	-0,237449	1,17059	-4,66	-3,32	17,25	0,6996	0,6926	100,13
BN	-0,4598217	0,047864	0,7775444	-7,18	0,89	15,17	0,6560	0,6480	82,01
BV	-0,3097747	-0,3179653	1,084155	-4,27	5,19	18,66	0,7548	0,7491	132,34
						Mean	0,7565	0,7508	

With reference to the individual significance Student test statistics, we reject the null hypothesis and accept the fact that each independent variable is significant at the 5% level, except the HML portfolio in explaining SN and BN. The overall significance of the model is always true for the six regressions at the 5% and 1% levels.

R^2 and adjusted R^2 vary between 0.6480 and 0.8525 with means of 0.7565 and 0.7508, respectively. The explanatory power remains strong but slightly lower than that of the ADI index.

C-The DJT index:

The table below reports the regression results of the model for the DJT index with the six composite portfolios as dependent variables:

Table-7. The regression results of the DJT index

Portfolio	SMB	HML	MKT	t(SMB)	t(HML)	t(MKT)	R^2	$\overline{R^2}$	F(3,129)
SG	0,9971181	-0,7186436	0,9902673	15,52	-10,40	17,39	0,8753	0,8724	301,93
SN	0,541188	-0,0403742	0,4428533	7,66	-0,53	7,07	0,4925	0,4807	41,74
SV	0,7922996	0,5826579	0,7816771	13,39	9,16	14,91	0,7561	0,7505	133,33
BG	-0,3262891	-0,422627	0,5833639	-4,81	-5,80	9,71	0,5543	0,5439	53,47
BN	-0,2216345	-0,0298042	0,8394796	-2,99	-0,37	12,77	0,5781	0,5683	58,91
BV	-0,1214707	0,2760714	0,7919542	-2,22	4,70	16,34	0,6856	0,6783	93,78
						Mean	0,6569	0,6490	

The study of these same regressions on the DJT index resulted in the same conclusions. All variables are significant at the 5% level, except HML when explaining SN and BN. The overall significance of the model is ensured for the two threshold values (5%, 1%). R^2 and adjusted R^2 range from 0.4925 to 0.8753 and 0.4807 to 0.8753, respectively. The respective means are 0.6569 and 0.6490, lower than those of ADI and DJI. The explanatory power is more than average.

D- The DJU index:

Table (1-8) lists the regression results of the model for the DJU index with the six composite portfolios as dependent variables:

Table-8. The results of the regression of the index DJU

Portfolio	SMB	HML	MKT	t(SMB)	t(HML)	t(MKT)	R^2	$\overline{R^2}$	F(3,129)
SG	0, 9391291	-0,6171349	0,8935451	10,31	-7,54	10,78	0,8609	0,8577	266,13
SN	0,3064033	-0,0362648	0,7979212	4,13	-0,54	11,82	0,6811	0,6737	91,84
SV	0,621868	0,6984474	1,112374	7,93	9,90	15,58	0,7516	0,7459	130,13
BG	-0,5964356	-0,3782166	1,075821	-8,71	-6,14	17,25	0,7526	0,7468	130,80
BN	-0,2569896	0,117063	0,8710286	-3,16	1,60	11,75	0,5179	0,5066	46,18
BV	-0,2791744	0,3062011	0,8569915	-3,50	4,27	11,81	0,5359	0,5252	49,66
						Mean	0,6833	0,6759	

With reference to the individual significance Student test statistics, we reject the null hypothesis for all variables except for HML when explaining SN and BN. Therefore, the variables are significant at the 5% level. The overall significance is ensured for the two 5% and 1% thresholds.

R^2 and adjusted R^2 have values ranging from 0.5179 to 0.8609 and 0.5252 to 0.8577, respectively. Their means are 0.6833 and 0.6759, respectively, a more than average explanatory power, which is lower than DJA and DJI and greater than DJT.

• A General Discussion:

The study of regressions on these four markets leads to mixed conclusions. If we consider only the first three markets (DJA, DJI and DJT), we note that explanatory power increases with the number of firms in the index. However, for the DJU index, which is the index with a minimum number of firms, its explanatory power is not the lowest. Table (9) summarizes the results:

Table-9. Summary of results

Index	Number of firms	Explanatory power : $\overline{R^2}$
DJA	65	0,7857
DJI	30	0,7508
DJT	20	0,6490
DJU	15	0,6759

It should be noted that the DJA index consists of all firms components of the three other indices. Hypothesis 1 is confirmed if we consider only the first three indices. However, DJU explanatory power remains lower than DJA and DJI.

Table (10) reports the explanatory power of the model for each dependent variable and for each index:

In this table, the independent variable SG still has the strongest explanatory power, with a mean of 0.8547 and the BN portfolio exhibits the lowest mean, i.e. 0.6709. Hypothesis 1 and 2 are not verified for all elementary portfolios. However, it should be noted that the deletion of the DJU index will lead us to accept the first hypothesis for the variables SN, BG and BN on the one hand, and the overall model on the other hand.

Table-10. Explanatory power by regression

Portfolio	$\overline{R^2}$ DJA	$\overline{R^2}$ DJI	$\overline{R^2}$ DJT	$\overline{R^2}$ DJU	Mean
SG	0,8398	0,8491	0,8724	0,8577	0,8547
SN	0,7659	0,7521	0,4807	0,6737	0,6681
SV	0,8062	0,8143	0,7505	0,7459	0,7792
BG	0,8085	0,6926	0,5439	0,7468	0,6979
BN	0,763	0,648	0,5683	0,5066	0,6214
BV	0,7312	0,7491	0,6783	0,5252	0,6709
Mean	0,7857	0,7565	0,6490	0,6759	

In summary, the explanatory power of the Fama-French three-factor model is not affected by index size in absolute terms, therefore hypothesis 3 is confirmed. However, if we only consider DJA, DJI and DJT indices, we accept hypothesis 1. The same is true, if we consider DJA, DJI and DJU indices. The problem lies, therefore, in DJT and DJU size (respectively, 20 and 15 firms) which seemed to have biased our study.

This study had two objectives: one explicit and the other implicit. The explicit is to test the relationship between the explanatory power of the Fama-French three-factor model and index size. Fama and French (1992a) and Fama and French (1993) used a uniform size of the considered index, one hundred stocks. However, world indices are different in size. Therefore we should absolutely study the impact of variation in index size on the relevance of the model. The implicit objective is to check market efficiency. Referring to the strong $\overline{R^2}$ values, we could conclude that stock returns can be expected from HML and SMB portfolios returns and market returns. Therefore, the four studied indices are not efficient under a strong form. This result corroborates that of Cutler David *et al.* (1989) and Shiller Robert (1981).

Moreover, our study found a positive relationship between index size and $\overline{R^2}$, provided that the difference between indices size is strictly greater than five firms. Therefore, we can conclude that the Fama-French three-factor model is more useful for markets and indices having a larger number of firms. However, one should consider the same problem for Fama-French four-factor and five-factor models.

In this paper, we tried to examine the concept of market efficiency. This notion is of paramount importance in the finance. With it, we can classify markets according to their degrees of efficiency and, if possible, make gains and beat the market.

Technological development has contributed greatly in enhancing market efficiency by increasing information absorption rate. Therefore, it has become very difficult to make a profit, except by chance, especially in developed markets.

In our empirical section, we compared the explanatory power of the Fama-French three-facto model in four markets different in size. We found a positive relationship between the number of firms in an index and explanatory power. Therefore, we can conclude that the investor can better predict a stock price using the Fama-French three-factor model, in a larger market and make profits.

In summary, efficiency of a market or an index is a decreasing function of its size. A smaller number of stocks allow investors to better control information and predict price movements. In the presence of anomalies, arbitrageurs will instantly react and restore balance. However, this result cannot be generalized because we only studied U.S. indices.

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