Testing and comparing conditional CAPM with a new approach in the cross-sectional framework

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Abstract. This study examines the conditional relationship between beta and return for stocks traded on S&P 500 for the period from July 2001 to June 2011. The portfolios formed based on the Book value per share and betas using monthly data. A novel approach for capturing time variation in betas whose pattern is treated as a function of market returns is developed and presented. The estimated coefficients of a nonlinear regression constitute the basis of creating a two factor model. Our results indicate that the proposed specification outperforms alternative models in explaining the cross-section of returns.

Keywords: Cross-sectional regression; CAPM; S&P 500;

1 Introduction

This study aims at examining the conditional relationship between beta and returns using three well-known models (i.e. CAPM, Fama and French three factor model (FF3FM), Premium Labor- model (PLM)) and a new one which in view of the strong evidence of betas instability, it tries to capture their time variation, considering their pattern as a function of market returns. Our findings suggest that this specification outperforms alternative models, previously proposed in the literature, in explaining the cross-section of returns.

The Capital Asset Pricing Model (CAPM) developed by Sharpe (1964) and Lintner (1965) quantifies the risk return relationship, suggesting that the only relevant risk measure is the beta coefficient, which reflects the systematic risk. Due to the powerful and intuitively pleasing predictions (Fama and French, 2004) the model is still widely used by financial managers and investors to estimate the risk of the cash flow, the cost of capital and the performance of managed funds (Fletcher, 2000; Tang and Shum, 2003; Perold, 2004).

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Fama and MacBeth (FMcB) (1973) conducted the first empirical examination regarding the validity of the CAPM. They found that on average a positive trade off exists between return and risk, leading to a conclusion in favour of the CAPM. However, empirical evidence in 1990s (e.g. Jegadeesh, 1992; Davis, 1994; Fama and French, 1996, Groenewold and Fraser, 1997) expresses doubts with regard to the validity of betas as risk measures, since their findings suggest that betas are not always significantly related to returns.

The limited empirical support found for the CAPM is interpreted in the literature either as evidence against the CAPM itself or as evidence that the testing methodology is not suitable. As far as the former case is concerned, the literature presents alternative tests of measures to the market premium factor suggested by the CAPM. For example, Banz (1981) finds that the size effect has a strong impact on stock returns, indicating that smaller firms have higher returns and thus higher betas. Similar findings are obtained by Zarowin (1990), Fama and French (1992) and Daniel and Titman (1997). Measures, such as book to market value and earnings to price ratio, appear to significantly influence the stock returns (Berk, 1995; Fama and French, 1996). Stocks with high such ratios tend to have higher returns than stocks with low such ratios. Similar results have been found by Chan et al. (1991) for the Japanese market and Levis and Liodakis (2001) for the UK market. Liquidity also appears to influence the expected stock returns as explained by Jacoby et al. (2000) while Chen (1983) and more recently Groenewold and Fraser (1997) conclude that the Arbitrage Pricing Theory (APT) of Ross (1976) outperforms the CAPM.

In addition, the stability of beta coefficient over 'bull' and 'bear' market conditions is also assumed. However, Levy (1974) proposed that beta may differ with market conditions and inferences based on the stable nature of beta can be proved misleading. Fabozzi and Francis (1977) first tested the stability of betas over the 'bull' and 'bear' markets. Defining these specific conditions with three different ways, no evidence was found to support the hypothesis that the stock market affects betas asymmetrically. Clinebell et. al. (1993) also show that observed differences of beta coefficients between Bull and Bear market conditions are significant. Woodward and Anderson (2009) applying a logistic smooth transition market model (LSTM) for Australian industry portfolios report that bull and bear betas are significantly different for most industries while the transition between bull and bear states is rather abrupt. Wiggins (1992) finds the dual beta model of Fabozzi and Francis (1977) to explain better the portfolio returns formed by size, past beta, and historic return performance. Bhardwaj and Brooks (1993) conclude that there is not size premium when beta varies in up and down markets as small firm stocks underperform large firm stocks.

The FMcB testing methodology has been criticized for a number of reasons. Roll (1977) argued that the CAPM cannot be tested because the composition of the real market portfolio is not observed. Isakov (1999) reported that this particular methodology does not leave beta to appear as a useful measure of risk as the model is expressed in terms of expected returns but tests can only be performed on realized returns. In addition, the realized market excess return does not behave as expressed since it is too volatile and is often negative. Pettengill et al. (1995) proposed an alternative approach with which the excess market returns are separated into positive and negative, concerning that investors perceive the possibility of the risky assets' return being below the risk-free rate. However, the FMcB procedure is still used in most empirical studies (Fraser et al., 2004) for testing models in the cross- sectional framework.

The paper is organized as follows. Next section develops the methodology for the models' empirical examination, section 3 describes the data and reports the empirical findings, while section 4 concludes the paper.

2 Methodology

In this study three model previously presented in the literature will be compared against our proposed methodology. The three models is the well-known Capital Asset Pricing Model, the three-factor model suggested by Fama and French (1996) and the Premium-Labor model (PL-model) developed by Jagannathan and Wang (JW) (1996) Due to space limitations we will not present this models here but refer the reader to Fama and French (1996) and Jagannathan and Wang (1996). In this study we will focus on a novel approach, the Two Factor Model.

2.1 A new approach: Two Factor Model

Two steps constitute the new approach we use here for catching up any variations in beta coefficients. The first step contains the estimation of beta coefficients from equation:

$$R_{it} - R_{ft} = a_i + \beta_i (R_{mt} - R_{ft}) + e_{it} \tag{1}$$

with $R_{it} - R_{ft}$ being the excess return of asset i, $R_{mt} - R_{ft}$ the market excess return, β_i the systematic risk and α_i and e_{it} are assumed to be zero according to the model

Using standard OLS method and daily returns data of three years time interval, since this particular period has been found to give the best daily beta predictions (Daves et. al., 2000), we get the first estimated beta coefficient of period t. Next, a rolling regression is applied. More precisely in order to obtain the second value of beta, the first observation is dropped and a new is added to the end of the sample. The procedure is followed for a five-year period estimating the respective betas of each day. Having around 1250 betas at hand, we rank them in ascending order relative to the market return on day t=1…1250.

Then, the averaged values of the estimated betas for each market return discrete interval are calculated. This way ensures the equality weights given at each observation catching up any differences in each and every market condition. At the same time, we avoid any subjective bias at the selected market interval. Being able to construct the used variables, a question arises regarding the form of beta coefficient as a function of R_{ms} (i.e. $\overline{\beta} = f(R_{ms})$, (Faff and Brooks, 1998)). Lin et al., (1992) suggest that beta mean fluctuates around an upward or downward parabolic trend pattern. Hence, we approach the functional form of $f(\cdot)$ by equation (8):

$$\overline{\beta} = \alpha * \exp^{(b*R_{ms} + c*R_{ms}{}^{2} + u)} \tag{2}$$

where α, b, c are the coefficients to be estimated, R_{ms} is the sorted market return, $\overline{\beta}$ are the average betas corresponding to each market return interval and u are the residuals. We do not make any assumption about the residuals distribution as we are interested in only for the magnitude of the estimated coefficients.

Through linearization and assuming that beta coefficients are nonnegative as usually happens in financial contexts (Andersen et al., 2006), equation (8) takes the following shape:

$$\ln(\overline{\beta}) = \ln(a) + b * R_{ms} + c * R_{ms}^{2} + u \tag{3}$$

If f is continuous in the interval $\left[R_{ms}^{-}, R_{ms}^{+}\right]$ and twice differentiable then $\frac{1}{\overline{\beta}}\frac{\partial\overline{\beta}}{\partial R_{m}} = (b + 2cR_{ms})$ or $\frac{\partial\overline{\beta}}{\partial R_{ms}} = \overline{\beta}(b + 2cR_{ms})$ and $\frac{\partial^{2}\overline{\beta}}{\partial R_{ms}^{2}} = 2c\overline{\beta}$. For $\overline{\beta}$ >0 and c=0, f is linear as well as concave. If c>0, f is convex as the second derivative is positive, while for c<0 f is concave with negative second derivative. Besides, $\frac{\partial\overline{\beta}}{\partial b} = \overline{\beta}R_{ms}^{2} > 0$, which shows that an increase in b will increase the β coefficient. Thus the function is increasing for b>0 and decreasing for b<0.

We proceed to the construction of a two-factor model (hereafter TFM) where the variables are formed based on the b_coefficients of equation (3). We expect that stocks with positive b_coefficients should give higher returns without an increase in the risk. The intuition behind this stems from the fact that at each state of market return nature, the expected return of security i is higher. So, we could say that 'Superior' stocks are the ones with increasing beta coefficient as market return increases and vice versa for the 'Inferior' stocks. A 'Superior' stock should contain all those characteristics that make it to appear higher returns than its competitors. For example, it could be a stock with relatively low leverage and in bad states of the world its beta coefficient to not increase as much as another stock with high leverage values (Jagannathan and Wang, 1996). Thus, the first variable named as 'SMISI' (i.e. Superior minus Inferior Stock Index) represents the difference in returns between the 30% of stocks with the highest b_coefficients and the 30% of stocks with the lowest b_coefficients. This variable aims at capturing the risk associated with 'Superior' and 'Inferior' stocks. The second explanatory variable, which we call it as 'Neutral' (Neutral Stock Index-NSI), is the remaining 40% of the stocks. The stocks constitute the index have on average zero b_coefficients. This index is supposed to be similar to the general index of S&P 500 if the assumption of constant betas coming from the CAPM holds. The time series regression is given by the following equation:

$$R_{it} - R_{ft} = a_{i} + c_{i}\,SMISI_{t} + n_{i}\,NSI_{t} + e_{it} \tag{4}$$

and the unconditional cross-section regression is:

$$r_{i} = \lambda_{o} + \lambda_{smisi}\,\hat{c}_{i} + \lambda_{nsi}\,n_{i} + z_{i} \tag{5}$$

3 Empirical Results

3.1 Data description

The dataset used concerns securities traded on the S&P 500. The rate of return of each security, R_i, at time t is calculated as $R_{it} = P_{it} / P_{it-1} - 1$. The testing period spans from July 2001 to June 2011. The risk free rate is a 3-month Treasury bill for the US market. For the construction of the variables used in the TFM we firstly employ daily observations for the estimation of the b_coefficients as mentioned above. To be included in one of the 'Superior' or 'Inferior' portfolio for a given year a stock must have statistically significant beta coefficients at least at 10% level (i.e. t-stat $|1.70|$) for all previous 5 years. This way, we ensure that each beta coefficient has explanatory power and that it can be used for estimation purposes. After forming the portfolios, monthly returns are employed. The monthly return observations of the FF3FM are retrieved from the authors' internet homepage[2]. For the PL_model the same variables used by JW are also employed here. The bond yields of BAA and AAA used as the premium in the PL-model. Similarly the per capita monthly income series was obtained from the Federal Reserve Bulletin published by the Board of Governors of the Federal Reserve System and was used as the labor variable. Following JW, the growth rate in labor income is computed as:

$$R_t^{labor} = [L_{t-1} + L_{t-2}] / [L_{t-2} + L_{t-2}]$$

where L_{t-1} is the per capita labor income for month t-1, which becomes known at the end of month t.

The models are tested on two different portfolios sorted on the historical beta coefficients and the Book Value per share. The beta based portfolios are formed following the standard FMcB methodology. The first five years of monthly observations (i.e. t-120,…,t-61) are used to estimate the betas for each security. Stocks with statistically significant betas higher than the 10% level were excluded from the sample. After estimating the stocks' β_i coefficients from equation (1), the stocks were ranked on the basis of estimated betas and were assigned to one of the ten portfolios. The first portfolio consisted of stocks with the lowest betas, while portfolio 10 consisted of stocks with the highest betas. This process was then completed for each subsequent year in our data set. This gives a time series of monthly returns from July 1996 to June 2011 for each of the ten portfolios. After forming the portfolios, the beta of each portfolio is then estimated over the second period of 5 years (i.e. t-60,…,t-1) regressing now the realized portfolio returns on the market index. This is done in order to reduce the 'errors in variables' problem. The second kind portfolios are formed every calendar year, starting in 2001, where we first sort firms into deciles based on their Book Value per share at the end of June. For consistency purposes, the beta portfolios have the same starting point every year. The Book-Value per share data were taken from Compustat.

Following Fraser et al. (2004), we repeat this procedure by updating the beta estimates on a monthly basis. Thus, time series of risk premiums of the models are gener-

[2] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

ated. The test of significance of the risk-premia is done as follows (Fama and MacBeth, 1973; Clare and Thomas, 1994):

$$t_{\lambda} = \frac{\lambda}{s(\lambda)/\sqrt{n}} \tag{6}$$

In the above equation, λ is the mean value of the estimated risk premium, $s(\lambda)$ is the standard deviation and n shows the number of observations. The variables are priced over the estimation period at the 10 per cent level, when $|t|$ is greater than 1.30.

The relatively low number of available stocks at the very early stage of the sample could cause survivorship bias. To examine possible effects related to survivorship bias, we also form big and small sample portfolios. The small sample portfolios contain stocks that were used in the construction of the TFM. This is due to the fact that during the construction of the variables, the asked number of observations is higher (i.e. 8 years). The big sample portfolios contain stocks with statistically significant betas at least at the 10% level. Although the higher number of data availability the BVps portfolios are also formed from those stocks. For compatibility reasons between the two different kind of portfolios, we chose to reduce the number of stocks by 10% on average. Figure 1 depicts the number of shares contained in the two samples as well as the available data of the BVps.

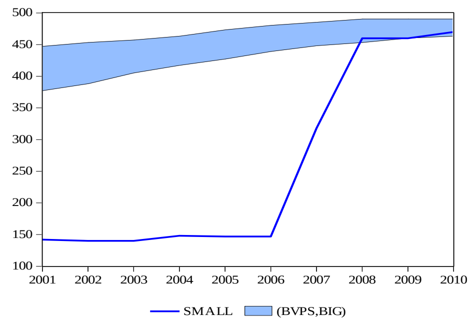

Fig. 1. Number of shares in analysis

The summary statistics results indicate the existence of positive differences in returns between the lowest and highest BVps portfolios and highest and lowest beta based portfolios. In addition, the portfolio returns pattern does not differentiate significantly between the big and small samples. A deviation is only observed between the 9^{th} and 10^{th} decile of small sample beta sorted portfolios. The estimated average betas produced by CAPM look similar within portfolios formed on BVps. However, this is not the case of beta-sorted portfolios as they range from a low of 0.47 to a high of 1.65. In addition, at both samples the slopes seem to follow identical pattern.

Following the method of Banz and Breen (1986) we examine whether the returns over the 120 months for each portfolio are different. For brevity reasons, we discuss only the results of the Gibbons, Ross, Shanken (1989) test (hereafter GRS test) of the zero a's hypothesis. The findings support that jointly a's are different from zero and statistically significant differences in returns between the big and the small sample exist. However, a more closely examination of portfolios indicates that only three out of ten and one out of ten cases are different from zero for the BVps and beta portfolios respectively.

3.2 Unconditional and Conditional cross-section regressions

Panel A of table 1 depicts the evidence of the unconditional cross-sectional regressions from July 2001 to August 2011. It tries to identify risk premiums associated with factors other than market risk. As we can see, the coefficients λ_0 are not statistically different from zero for the BVps portfolios. This is consistent with the Sharpe-Lintner hypothesis (SLH). The R^2 of the regression is only 0.7% for the case of CAPM while it goes up to 70% and 90% for the TFM and FF3FM respectively. The SMISI factor is priced and the market risk premium has the expected positive sign apart from the case of FF3FM though not significant at any level. As for the PL-model, it has relatively low R^2 while neither labor factor nor premium factor influence the returns. The results of the portfolios formed on beta coefficients are rather different. The R^2's increase and reach as high as 84.9% for the PL-model with the rest models to follow closely. Two intercepts appear to be significant violating the SLH while the FF3FM appears high R^2 value although none of its factors are priced. Panel B of Table 5 depicts the results for the period from July 2006 to August 2011. The TFM continues to have relatively high R^2 values with the FF3FM to lose power relatively to its previously observed R^2 values. CAPM still retains the poor performance consistent with the results of JW with PL-model to perform better in terms of R^2. The same tests[3] have been also carried out using the small sample. The findings differ significantly with regard to R^2 values which appear to be lower.

Table 1: Unconditional Cross-sectional regressions of the selected models.

Panel A: 2001-2011	λ_0	λ_1	λ_{SMISI}	λ_{NSI}	λ_{SMB}	λ_{HML}	λ_{labor}	λ_{prem}	R^2
BV per share	0.014	-0.004							0.007
	(0.75)	(-0.24)							
	-0.009		0.042	0.018					0.701
	(-0.75)		(3.74)*	(1.54)					
	0.009	-0.008			0.023	-0.002			0.914
	(0.78)	(-0.57)			(2.53)*	(-0.30)			
	0.009	0.004					-0.006	1.305	0.244
	(0.03)	(0.11)					(-0.99)	(0.93)	
Beta portfolios	0.003	0.005							0.825
	(2.98)*	(6.15)*							
	0.004		-0.002	0.005					0.828
	(2.10)**			(-0.34)	(3.11)*				

[3] The results are available from the authors upon request.

	0.002	0.008			-0.002	0.001			0.833
	(0.95)	(1.80)			(-0.36)	(0.48)			
	0.006	0.006					0.001	0.201	0.849
	(1.36)	(2.37)**					(0.91)	(0.85)	
Panel B: 2006-2011	λ_0	λ_1	λ_{SMISI}	λ_{NSI}	λ_{SMB}	λ_{HML}	λ_{labor}	λ_{prem}	R^2
	BV per share		0.030	-0.019					
0.456		(3.52)*	(-2.59)*						
	0.014		0.022	-0.006					0.762
	(1.87)		(4.45)*	(-0.78)					
	0.003	0.003			0.003	-0.012			0.879
	(0.47)	(0.45)			(0.73)	(-2.83)*			
	0.028	-0.013					0.000	0.355	0.496
	(2.32)**	(-0.96)					(0.64)	(0.21)	
Beta portfolios	-0.001	0.018							0.006
	(-0.01)	(0.22)							
	-0.192		0.526	0.221					0.559
	(-2.13)**		(2.92)*	(2.47)*					
	-0.055	0.135			-0.069	-0.318			0.323
	(-0.17)	(0.33)			(-0.23)	(-1.05)			
	-0.209	0.363					0.144	-3.06	0.642
	(-1.19)	(3.01)*					(2.59)*	(-0.37)	

*,** depict significance at 5% and 10% respectively.

The results of the conditional cross-sectional regressions are presented in table 2. The risk premia are demonstrated in the first column, the second column shows the t-ratio with the third and fourth columns to depict the normality test and the average GRS test coming from the time series first step regression respectively. We firstly note that in the case of BVps portfolios the variables of the TFM are priced though a proportion of portfolio returns left unexplained. This also happens with CAPM, while the market risk and the HML factor in the FF3FM appear to be significant with the constant not being statistically different from zero. Related to PL-model no factor is significant. The t statistics should be cared with caution, since in some cases the distribution of the estimated risk premia are clearly not normal, a result consistent with Clare and Thomas (1994) when macro-economic variables were used. For the beta based portfolios we have to refer that almost no risk premia are priced apart from the case of PL-model. The GRS test depict that TFM clearly outperforms CAPM and FF3FM models in the first step time series regressions. The test is not available in PL-model since the regressions have been conducted separately for each one of the variables. The same tests have been also carried out using this time the estimated betas constant for one year as exactly FMB done in their study. Once again the variables of the TFM are priced with this model along with the PL-model to be the better ones when the period from July 2006 to June 2011 is considered.

Table 2: Estimated risk premia in conditional cross-section regression.

Panel A: 2001-2011			λ_k	t	JB	GRS test
BVps	CAPM	λ_0	-0.011	-2.06*	8.73	
		λ_1	0.024	4.18*	5.83*	16.4
	TFM	λ_0	-0.018	-2.77*	35.8	
		λ_{SMISI}	0.019	2.56*	22.7	
		λ_{NSI}	0.032	3.97*	53.7	2.97*
	FF3FM	λ_0	-0.004	-0.53	739.4	
		λ_1	0.017	1.61*	627.4	
		λ_{SMB}	0.007	1.13	35.1	
		λ_{HML}	-0.012	-2.07*	4.80*	10.36
	PLM	λ_0	0.004	1.03	651.2	
		λ_1	-0.001	-0.11	67.4	
		λ_{prem}	0.000	-0.11	17.1	
		λ_{labor}	0.012	0.08	0.27*	N/A
Panel B: 2001-2011			λ_k	t	JB	GRS test
Beta port.		CAPM	λ_0	0.003	0.88	26.0
		λ_1	0.006	1.03	50.5	11.9
	TFM	λ_0	0.004	0.80	28.1	
		λ_{SMISI}	0.001	0.08	33.5	
		λ_{NSI}	0.005	0.62	47.8	1.39*
	FF3FM	λ_0	0.006	1.64*	16.6	
		λ_1	0.002	0.47	20.9	
		λ_{SMB}	0.001	0.12	1733.1	
		λ_{HML}	-0.003	-0.60	68.9	5.52
	PLM	λ_0	-0.008	-1.46*	0.30*	
		λ_1	0.025	3.49*	11.9	
		λ_{prem}	0.002	1.35*	90.7	
		λ_{labor}	0.041	0.27	466.2	N/A

* depicts significance at 10% level

4 Conclusions

This paper examines the efficacy of different models to explain the relationship between expected return and risk in the cross-sectional context. We introduce a novel approach which is primarily based on the time varying nature of betas. The new TFM incorporates two variables. The first one is the 'SMISI' and captures the risk associated with the difference between 'Superior' and 'Ineferior' stocks whose betas are increasing and decreasing in market return respectively. The second variable, the 'NSI', is constituted from invariant betas and operates as the market factor.

The study shows that in the cross-sectional analysis both conditionally and unconditionally, the stock market prices different risk factors. Related to the BVps portfolios, the SMISI factor is priced and the market risk premium has the expected positive sign apart from the case of FF3FM though not significant at any level. As for the PL-model, it has relatively low R^2 while neither labor nor premium factors influence the returns. The results of the portfolios formed on beta coefficients depict that PL-model increases its R^2 with the rest models to follow closely. In addition, two intercepts violate the SLH as they appear to be statistically different from zero.

The conditional cross-sectional regressions in the case of BVps portfolios identify the power of the TFM variables in explaining asset returns even though a proportion of them left unexplained. This also happens with CAPM, while the market and the HML factors in the FF3FM appear to be significant with the constant not being statistically different from zero. Related to PL-model no factor is priced. For the beta sorted portfolios, we should refer that almost no risk premia are priced apart from the case of PL-model. In addition, the GRS test calculated in the first step time series regressions depict the outperformance of TFM in relation to CAPM and FF3FM models.

The implications of this study show that there are additional factors other than the market risk that affect stock returns. The new risk factors which found to be significant both in time series and cross section analyses, give valuable information of better understanding the characteristics of returns, targeting the reinforcement of stock market efficiency.

For future research we plan to study the performance of our model in extreme market conditions.

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