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IS THE CAPM DEAD OR ALIVE IN THE BRAZILIAN MARKET?

Joe Akira Yoshino & Edson Bastos e Santos**

Abstract: The central purpose of this work is to test the Sharpe-Lintner-Black Capital Asset Pricing Model in the Brazilian equity market. We have concluded that the CAPM is dead in the Brazilian equity market because, besides using the market premiums to explain the panel equity premiums, there are also some anomalies, such as, the firm size, the equity price-to-book value, the dividend yield, and the price-earnings ratio. Furthermore, by using the recent panel cointegration FMOLS (fully modified OLS) estimator, this paper corroborates the Fama & French three-factor model (1992, 1993). This work finds also two new three-factor models to explain the local market that satisfy the non-arbitrage condition. These results are important for the purpose of asset pricing and hedging in the Brazilian equity market.

JEL Classification: G12

Keywords: asset pricing, panel CAPM, Fama and French's three-factor model, style indexes

INTRODUCTION

The CAPM (Capital Asset Pricing Model) developed by Sharpe (1964), Lintner (1965), and Black (1972) proposes: (i) the expected return on equity $E(R_t^i)$ is a positive linear function of its systematic risk β_i ; and (ii) the market risks β_i 's are enough to explain the cross-section variations of expected returns $E(R_t^i)$. Consider the following regression

$$\hat{E}(R_t^i - R_t^f) = \gamma_0 + \gamma_1 \beta_i + \eta_t^i \quad (1)$$

where

$$\beta_i = \frac{Cov(R_t^i, R_t^m)}{Var(R_t^m)}, \quad \eta_t^i \sim N(0, \sigma_i^2) \text{ iid}, \quad (2)$$

$\hat{E}(R_t^i - R_t^f)$ is an unbiased and consistent estimator of $E(R_t^i - R_t^f)$, R_t^m is the market portfolio return whose variance is given by $Var(R_t^m)$, and $i = 1, \dots, N$, where N is the stock sample size.

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If we take expectations on both sides of equation (1) and verify the plausibility of $\gamma_0 = 0$ and $\gamma_1 = E(R_t^m - R_t^f)$, then, we have a description of the capital security market line, i.e.,

$$E(R_t^i - R_t^f) = \beta_i E(R_t^m - R_t^f). \quad (3)$$

The usual hypothesis test is characterized by the following construction

$$H_0 : \gamma_0 = 0 \text{ and } \gamma_1 = E(R_t^m - R_t^f) \quad (4)$$

$$H_a : \gamma_0 \neq 0 \text{ or } \gamma_1 \neq E(R_t^m - R_t^f). \quad (5)$$

To validate the CAPM, the intercept γ_0 must be zero and the coefficient γ_1 has to be equal to the expected market portfolio return in excess of the risk-free rate $E(R_t^m - R_t^f)$. Despite its historical importance, this hypothesis test presents two obstacles that weaken its statistical relevance.

First, the estimator is attained by a two-stage estimation using OLS (ordinary least square). The first stage of the estimating procedure consists of regressing the excess return of each individual stock $R_t^i - R_t^f$ on the market excess return $R_t^m - R_t^f$, i.e.,

$$R_t^i - R_t^f = \alpha_0 + \beta(R_t^m - R_t^f) + u_t^i, \quad (6)$$

where, α_0 is the intercept, u_t^i is the error term satisfying the usual classical linear regression assumptions, and $t = 1, \dots, T_i$, where T_i is the sample size for each individual stock time series. In the second stage, we use the OLS method to estimate the parameters (γ_0, γ_1) of equation (1), that is, we regress the expected excess return estimator of each individual stock $\hat{E}(R_t^i - R_t^f)$ on the estimator $\hat{\beta}_i$ obtained from the first-stage regression, where the estimator $\hat{E}(R_t^i - R_t^f) = T_i^{-1} \sum_{t=1}^{T_i} (R_t^i - R_t^f)$ is unbiased and consistent with respect to $E(R_t^i - R_t^f)$. According to Miller and Scholes (1972), in the first-stage, the measurement error occurs for individual β_i 's. This problem causes a downward bias (toward zero) in the estimator $\hat{\beta}_i$. As a consequence, in the second-stage, the security market line is flatter than it should be, i.e., in equation (1), $\hat{\gamma}_1$ is not an unbiased estimator of γ_1 , the true value of expected excess market return $E(R_t^m - R_t^f)$.

Second, Fama and French (2004) call attention for the positive correlation in the regression residuals. This problem produces the downward bias in the OLS estimates of the standard errors in the cross-section regression slopes.

This paper addresses these issues for the Brazilian stock market (BOVESPA — Bolsa de Valores de São Paulo), where, in addition to the estimating difficulties just presented, there is only a limited number of listed companies, causing the estimation procedure to be more complex.

In their seminal work, to attenuate the measurement error problem, Black *et al.* (1972) and Fama and MacBeth (1973) aggregated stocks in portfolios sorted by some criteria, such as, β_i (market risk), firm size, the book-market value ratio, etc. However, this methodology is unfeasible to the Brazilian equity market because of the small-sample of equity stocks available for trading. For this reason, this work uses the fully modified OLS panel estimator, or simply FMOLS [Im *et al.* (2003), Levin *et al.* (2002), Maddala and Wu (1999), and Pedroni (2000, 2001)], that not only estimates both dimensions together, i.e., the time ($t = 1, \dots, T$) and cross-section ($i = 1, \dots, N$), but also deals with the measurement error problem, producing unbiased and consistent estimators. Another advantage of using the FMOLS estimator in our work is that the FMOLS method is robust to the existence of panel unit roots, that is, time-series returns may be non-stationary and cointegrated. We consider this approach new, since we are not aware of any work using the same econometric technique for testing the panel CAPM. We also compare the FMOLS with the usual OLS and check whether others factors would be important to explain the panel equity premium. The usual factor candidates are firm size, equity price-to-book value, price-earnings ratio, equity return, and dividend yield, variables that have been commonly used in the literature.

This paper is organized in the following way: Section 2 describes the data for composing the panel (cross-section of stocks over time), Section 3 presents the results for the panel CAPM tests, and Section 4 results for alternative models. Finally, Section 5 contains the conclusions.

THE DATA

In comparison to the NYSE, the São Paulo Stock Market (Bovespa) has a much more limited activity, with around 300 listed companies and not more than 200 stocks traded on a daily basis. The IBOVESPA is not only the most widely used index in the Brazilian equity market but also composed of around 52 stocks. Its annual volume in 2006 was 3.1 billion of Brazilian Reais (approximately 1.7 billion of American Dollars). Although there are 52 stocks comprising the index, we consider only the most representatives ones, accounting for almost 70% of the index value, resulting in a stock sample size equal to $N = 24$.¹ Nonetheless, it is important to remark that the IBOVESPA methodology is very different from S&P500 and the Dow Jones Industrial Average index, where market capitalization and price level are, respectively, crucial factors for a stock to be representative in the index composite. Stock representativeness in the IBOVESPA is directly linked to its liquidity in terms of financial volume and number of orders placed. For example, even if a listed company has both high market capitalization and high stock price, but if it is not frequently traded in the stock exchange, than that company will not be of great importance for the index. For a comprehensive discussion about the IBOVESPA methodology we refer to Bovespa (2008). Notwithstanding our sample consists of only 24 stocks, the IBOVESPA methodology suggests that it faithfully reflects the stock exchange trading activity for the Brazilian equity market.²

We have used monthly data for all variables which are described below and have attempted to handle three main issues, as follows:

- (A) First, the sample length of time goes from October, 1998 (1998:10) through October, 2006 (2006:10), but we have divided this sample in two: one for estimating purposes

(1998:10 to 2002:12) and another, the forecasting period, to validate the estimated model (2003:1 to 2006:10). The full sample does not consider both the Asian and Russian crisis that occurred in 1997 and 1998, but includes both the devaluation of the Brazilian Real currency and the Argentinean contagion effect that took place in 1999 and 2001.

- (B) Second, we have constructed a balanced panel, i.e., for $t_i = 1, \dots, T_i$ and $i = 1, \dots, N$, representing the dimensions of the panel, where T_i is the sample size of the observed returns of each individual stock i , and N is number of stocks, so that $T_1 = T_2 = \dots = T_N$. This property entails the data will range throughout the entire length of time and will be evenly distributed in equal time periods. To maintain the panel balanced, when we find missing values on a specific month in the time-series of any of the explanatory variables, we simply eliminate that month from our sample; and
- (C) Third, we consider a 4-month lag for those explanatory variables involving accounting information, such as the companies' earnings and equity book values in order to eliminate any linear dependence that might exist between these explanatory variables and the error term. It is important to remark that CVM (Brazilian Securities and Exchange Commission), the agency responsible for governing the capital market in Brazil, requires that financial reports comprising accounting information, such as balance sheet and income statement, are published quarterly by the companies used in our sample.

When we take these issues into consideration, we obtain a sample size for the estimating period of $N = 83$ months, and a sample size for the forecasting period of $N = 51$ months.

We have used the following variables to identify potential models, including the CAPM:

$[R_t^i - R_t^f]$: the individual equity premium. The monthly nominal stock return R_t^i minus the nominal daily inter-bank certificate of deposits (CD) rate R_t^f (compounded monthly). This is the dependent variable (LHS) in the panel regressions;

$[R_t^m - R_t^f]$: the market excess return. The nominal IBOVESPA return R_t^m minus the nominal daily inter-bank CD rate R_t^f (compounded monthly). This variable is the usual candidate for the first RHS variable in the regression when testing the CAPM;

$[MktCap]$: the market price of equity or market capitalization. To compute market capitalization, we used the closing price for the last business day of the respective month multiplied by the total number of shares obtained from the last published quarterly financial report;

$[LnMkt]$: firm size. This explanatory variable has been suggested by Banz (1981) and, later, used by Fama and French (1992). This variable may be expressed as $LnMkt = \log(MktCap)$;

- [BV]: book value of common equity plus balance-sheet deferred taxes per share. Both the book value and the number of common stock have been obtained from the last published quarterly financial report;
- [A]: total book assets per share. This is a 12-month trailing variable, that has been obtained by the summation of total assets from the last 4 published quarterly financial reports and divided by the number of common shares obtained from the last quarterly financial report;
- [E]: earnings (income before extraordinary items, plus income statement deferred taxes, minus preferred dividends) per outstanding common shares. This is a 12-month trailing variable, that has been obtained by the summation of earnings from the last 4 published quarterly financial reports and divided by the number of common share obtained from the last quarterly financial report;
- [PE]: Price-Earnings ratio. The P/E ratio is computed as stock price (P) divided by earnings (E) per share. We have used the closing price (P) for the last business day of the respective month and the earnings (E) just as described above. When this ratio is two, it means that if we pay P for the stock, then we will recover our investment with profits generated by the company within two periods;
- [DY]: Dividend yield. Dividend/equity price ratio: dividend yield. It is the relationship between the accumulated dividends paid in the period divided by the stock's price at the end of the period. This is a 12-month trailing variable, that has been obtained by summing dividends paid from the last 4 published quarterly financial report; and,
- [LnMktBV]: stock profile. This variable may be expressed as $LnMktBV = \log(MktCap / BV)$ and represents the premium (or discount) of the market price relative to its book "value". When market capitalization is small relative to equity book value, the stock is said to have value profile. Usually these companies operate in mature industries and investors' gains come primarily from dividends paid. On the other hand, when market capitalization is high relative to equity book value, then the stock is said to have a "growth" profile. Growth stocks operate in incipient industries and reinvest most of its earnings, so that investors' gains are obtained most from capital appreciation. See Rosenberg et al. (1985) and Fama and French (1992). Both market capitalization ($MktCap$) and book value of common equity (BV) have been obtained as described above.

Table 1 presents some basic statistics about the variables to test the Brazilian CAPM.

TESTING THE BRAZILIAN CAPM

According to equation (1), Lintner (1965) tests whether the intercept γ_0 is equal zero in the security market line. Under the null hypothesis presented in (null), it is necessary that the null hypothesis $H_0 : \gamma_0 = 0$ be also satisfied. Therefore, Lintner (1965) has constructed a t-test with the following limiting distribution:

Table 1
Basic Statistics Potential Variables for Testing CAPM. Monthly Data. Balanced Panel.
Brazil: 1998: 10-2006:10

<i>Ticker</i>	<i>Stock Risk (standard deviation)</i>	<i>Stock Sharpe ratio</i>	<i>Equity Premium $E(R_i - R_{cdr})$</i>	<i>LnMkt (size) Log (stock's price* outstanding shares)</i>	<i>LnMktBV Log (stock's price/book- value of a share)</i>	<i>price/ earnings per share (P/E)</i>	<i>Dividend Yield (DY)</i>
TNLP4	0.08	0.98	0.08	23.23	0.33	62	0.04
PETR4	0.12	0.15	0.02	24.74	0.52	7	4.50
VALE5	0.12	0.58	0.07	24.03	0.83	12	0.06
USIM5	0.11	1.07	0.11	21.63	0.71	177	0.07
CSNA3	0.10	1.05	0.11	22.29	0.46	12	0.21
GGBR4	0.11	0.90	0.10	22.00	0.38	6	0.06
CMET4	0.11	0.80	0.09	21.10	0.95	30	0.02
ELET6	0.09	1.05	0.09	23.54	1.34	20	0.08
BBDC4	0.09	0.86	0.07	23.56	0.54	9	0.06
ITAU4	0.07	0.89	0.06	23.75	0.91	9	0.04
EBTP4	0.14	0.93	0.13	22.05	0.72	19	0.02
TSPP4	0.12	1.03	0.12	22.60	0.86	49	0.01
ITSA4	0.08	0.89	0.07	22.59	0.28	6	0.06
AMBV4	0.07	0.76	0.06	23.55	1.53	26	0.03
CSTB4	0.12	0.86	0.10	21.30	0.89	12	0.08
VCPA4	0.11	0.69	0.08	21.93	0.38	48	0.03
UBBR11	0.09	0.99	0.09	22.62	0.25	8	0.09
GOAU4	0.09	0.97	0.08	20.87	0.50	4	0.09
SDIA4	0.07	0.96	0.07	20.86	0.37	6	0.06
TCSL4	0.16	0.66	0.11	21.08	0.49	35	0.02
ACES4	0.10	1.00	0.10	20.50	0.72	10	0.01
ARCZ6	0.24	0.40	0.10	22.37	0.76	81	0.03
EMBR4	0.13	0.79	0.10	22.66	1.30	12	0.04
B RTP4	0.07	0.93	0.07	22.62	0.15	31	0.03

$$\frac{\gamma_0}{\sqrt{\text{Var}(\gamma_0)}} \xrightarrow{D} \mathcal{N}(0,1). \quad (7)$$

Instead, we prefer the equivalent χ^2 -test which has limiting distribution equal to

$$\frac{\gamma_0^2}{\text{Var}(\gamma_0)} \xrightarrow{D} \chi_1^2. \quad (8)$$

It is worth noting that Chan and Chen (1988) have proposed a different approach for testing the null hypothesis in (4). Although, it seems that their test, when controlling the effects of firm size, has a better power, they relied on portfolio construction to estimate β_i 's, so that they could appropriately mitigate the measurement error, following the same *modus operandi* introduced by Black *et al.* (1972) and Fama and MacBeth (1973). As a consequence, this approach is not adequate when the number of stocks is small, as it is the case of the Brazilian equity market.

Moreover, we prefer the Gibbons *et al.* (1989) and MacKinlay (1995) procedure, which has a more appealing interpretation of the above mentioned chi-square statistic in terms of Sharpe Ratios.⁵

Considering the properties of minimum-variance frontier, Gibbons *et al.* (1989), and MacKinlay (1995) have showed that the t-test above is equivalent to

$$\frac{\gamma_0^2}{\text{Var}(\gamma_0)} = N \times \left(\frac{SR_q^2 - SR_m^2}{1 + SR_m^2} \right), \quad (9)$$

where SR_m is the Sharpe ratio for the market portfolio and SR_q is the Sharpe ratio for the tangent portfolio (the biggest Sharpe ratio among all stocks in the panel). Using the information contained in column 3 of table 1 we have $SR_q = 1.069$, which refers to the Sharpe Ratio of Usiminas (ticker: USIM5).⁶ Figure SharpeRatio reports these Sharpe ratios for the Brazilian stock market. Contemplating only our stock sample ($N = 24$), our market portfolio has a premium $R_t^m - R_t^f = 0.057$ and standard deviation $\sqrt{\text{Var}(R_t^m)} = 0.058$, resulting in a Sharpe

ratio for the market portfolio equal to $SR_m = 0.996$. Equation (9) becomes $\gamma_0^2 / \text{Var}(\gamma_0) = 1.816$, and, taking into account the statistic distribution in (8), we have a p -value of 0.18, therefore, considering a significance level of $\alpha = 0.05$ or $\alpha = 0.10$, we reject the null hypothesis that the intercept is zero for the security market line of the Brazilian equity market in the period 1998:10-2006:10.



Figure 1: Sharpe Ratio. BOVESPA: 1998:10-2006:10

Another concern is the existence of cointegration among the stocks' time series. Table 5 shows several panel unit root tests. These tests suggest that we cannot reject the null hypothesis that unit roots exist. Our approach for minimizing the occurrence of spurious regressions in a cointegrated panel is to use the FMOLS (fully modified OLS) estimator. Table 2 reports the Brazilian CAPM regarding both the OLS estimator for individual equities (estimating method (1) and the FMOLS estimator for the entire panel (estimating method (2)). Furthermore, the market premium is a significant factor to explain the stock premium for the panel (estimating method (2)). On one hand, this result does not contradict the CAPM, however, on the other hand, figure 2 shows a bad fit for the security market line (SML). Figure 3 corroborates this last assertion, showing that the CAPM (estimated by the OLS and FMOLS estimators) is not a reasonable asset pricing model because it predicts an equity premium that is much different from the actual one. This problem may emerge from several reasons, such as, the failure of CAPM, the definition of market portfolio, the ex-post data, and the possible measurement error for β_i (the systematic risk).

As a practical matter, if third parties use the CAPM to make buying and selling decisions of equity in the Brazilian market, and you are aware of this process, then if you have a better alternative pricing model, as the ones that we will propose in the next section, you will have a great advantage over these parties, so that, you may profit at their cost, just like an arbitrage.

TESTING ALTERNATIVE MODELS

The asset pricing models developed by Sharpe (1964), Lintner (1965), and Black (1972) is valid just when β_i (the systematic risks) is enough to explain the equity expected excess returns in a linear relationship. All idiosyncratic risks are diversified and these risks do not affect the equity pricing. On the other hand, several studies find that the cross-sectional variation in stock returns can be explained by both the market risks β_i 's and other factors, such as, the firm size (Banz, 1981), the book-to-market value [Rosenberg *et al.* (1985); Chan *et al.* (1991)], the leverage (Bhandari, 1989), and the price-to-earnings ratio (Basu, 1983).

Fama and French (1995) proposed a three-factor model. In addition to β_i , they considered other risks factors, such as *SMB* (the difference between the return on a portfolio of small stocks and the return on a portfolio of large stocks) and *HML* (the difference between the return on a portfolio of high-book-to-market values and the return on a portfolio of low-book-to-market values). Note that Fama and French (1995) have interpreted the variables *SMB* and *HML*, respectively, as firm size and stock profile. Although we have used the same variables (firm size and stock profile), we have calculated them in a distinguished manner, because Brazilian market practices are slightly different from those in the United States. As an example, the greater a positive *SMB* is the more representative of the group of small companies. On the other hand, the greater *LnMkt* is the more depicting of the group of large companies. Hence, we need prudence while interpreting the regression coefficients for the models used in this paper and the one developed by Fama and French (1995). For instance, there is evidence that small companies perform higher returns than large companies, so one would expect a positive regression coefficient for the firm size variable in Fama and French (1995), but would expect a negative coefficient in our model. In a similar fashion, the greater a positive *HML* is the more reflecting of the group of value stocks, however, the greater the *LnMktBV* is the more representative of the group of growth stocks.

Table 2
The Brazilian CAPM Monthly Data

Stocks		Estimating Method 1 estimator OLS $y = a + bx$			Estimating Method 2 estimator FMOLS $y = a + bx$		
		<i>a</i>	<i>b</i>	R^2	<i>a</i>	<i>b</i>	R^2
Panel						0.74 (7.90)	
1	TNLP4	0.02 (2.28)	1.06 (10.01)	0.56	0.01 (1.57)	1.17 (11.04)	0.60
2	PETR4	0.02 (1.8)	0.88 (9.50)	0.53	0.02 (1.79)	1.07 (11.49)	0.62
3	VALE5	0.04 (2.09)	0.56 (2.43)	0.07	0.03 (1.46)	0.77 (1.99)	0.13
4	USIM5	0.08 (5.15)	0.53 (2.61)	0.08	0.05 (3.15)	1.07 (5.01)	0.24
5	CSNA3	0.06 (4.41)	0.76 (4.26)	0.19	0.04 (2.51)	1.18 (6.1)	0.32
6	GGBR4	0.05 (3.20)	0.87 (4.62)	0.21	0.03 (1.95)	1.22 (6.78)	0.37
7	CMET4	0.07 (3.76)	0.43 (1.95)	0.05	0.06 (3.55)	0.51 (2.30)	0.06
8	ELET6	0.05 (4.31)	0.66 (4.32)	0.19	0.05 (3.67)	0.78 (5.09)	0.25
9	BBDC4	0.03 (2.49)	0.81 (5.56)	0.28	0.04 (3.72)	0.53 (1.49)	0.14
10	ITAU4	0.03 (2.94)	0.61 (4.81)	0.22	0.03 (3.04)	0.59 (4.65)	0.21
11	EBTP4	0.09 (4.20)	0.69 (2.54)	0.07	0.13 (5.66)	-0.03 (-0.11)	0.00
12	TSPP4	0.05 (3.21)	1.34 (7.16)	0.39	0.03 (2.03)	1.65 (8.81)	0.49
13	ITSA4	0.02 (2.18)	0.82 (6.86)	0.37	0.04 (3.62)	0.53 (1.44)	0.17
14	AMBV4	0.04 (3.30)	0.31 (2.28)	0.06	0.03 (2.83)	0.40 (5.13)	0.10
15	CSTB4	0.06 (3.19)	0.80 (3.69)	0.15	0.03 (1.45)	1.30 (5.64)	0.28
16	VCPA4	0.05 (2.92)	0.48 (2.21)	0.06	0.03 (1.68)	0.88 (4.25)	0.19
17	UBBR1	0.04 (3.48)	0.89 (5.81)	0.30	0.05 (3.85)	0.81 (5.26)	0.25
18	GOAU4	0.06 (4.56)	0.38 (2.32)	0.06	0.05 (3.54)	0.59 (3.50)	0.13
19	SDIA4	0.05 (4.72)	0.31 (2.39)	0.07	0.05 (4.86)	0.28 (4.44)	0.06
20	TCSL4	0.02 (1.00)	1.46 (5.21)	0.25	0.05 (2.33)	0.91 (3.1)	0.10
21	ACES4	0.05 (3.87)	0.72 (4.24)	0.18	0.04 (0.03)	1.02 (5.7)	0.29
22	ARCZ6	0.04 (0.95)	1.06 (2.26)	0.06	0.01 (0.28)	1.51 (3.67)	0.12
23	EMBR4	0.07 (3.6)	0.46 (1.90)	0.04	0.06 (3.18)	0.62 (2.52)	0.07
24	B RTP4	0.03 (2.95)	0.69 (5.54)	0.28	0.02 (2.11)	0.84 (6.86)	0.38
Average		0.05	0.73	0.20	0.04	0.84	0.23
Std		0.02	0.30	0.15	0.02	0.39	0.17

(): t-student. y: stock excess return over risk-free rate (daily interbank CD); x: excess return of IBovespa over risk-free rate.

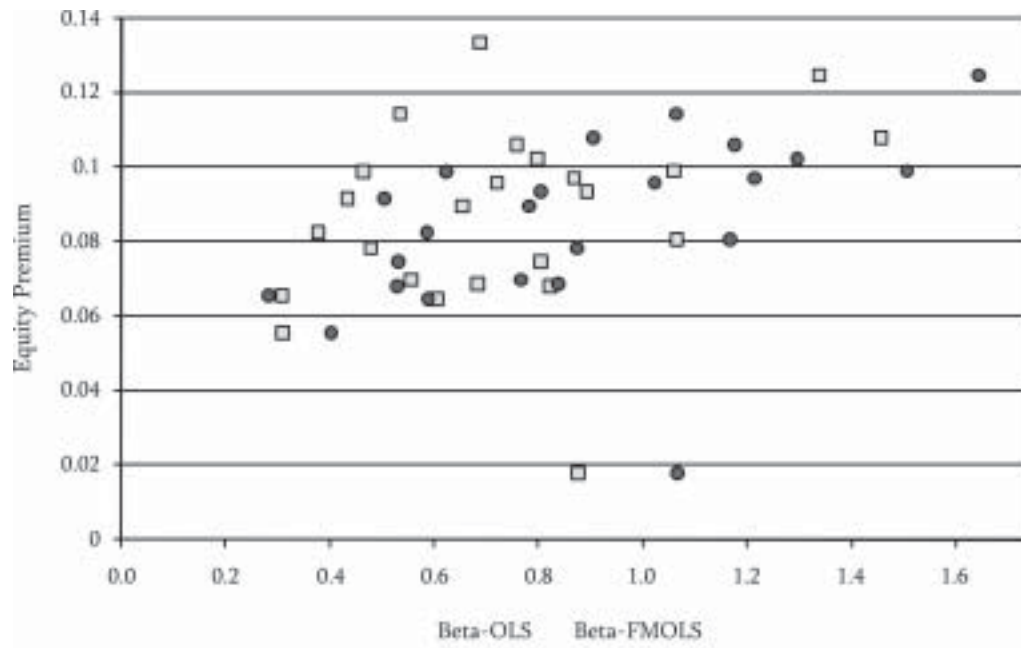


Figure 2: The Brazilian Security Market Line

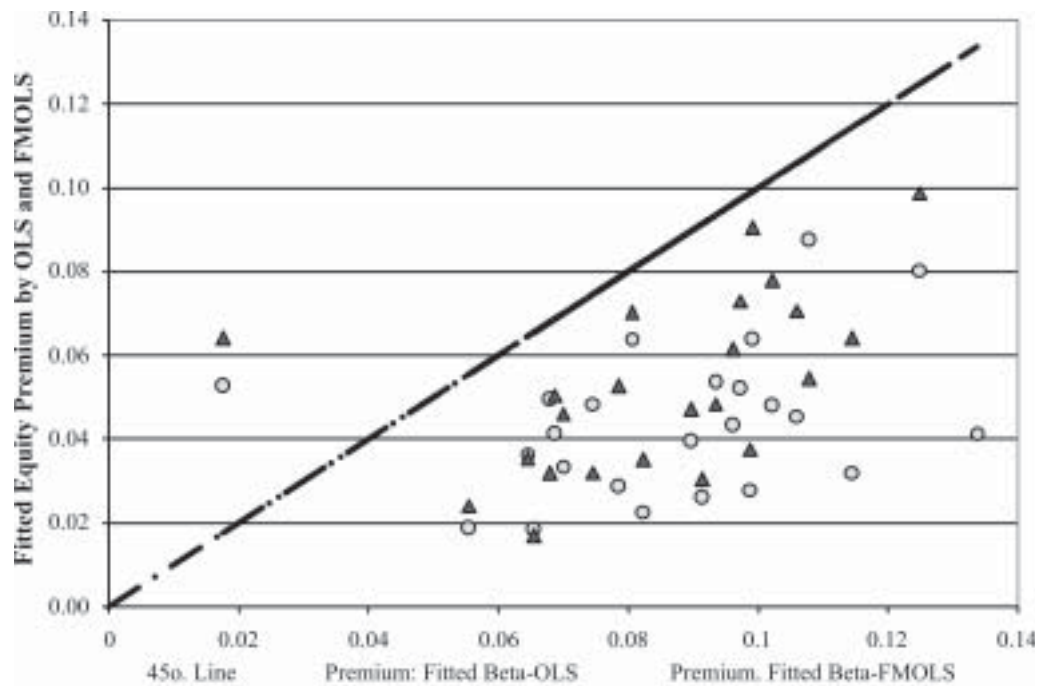


Figure 3: The CAPM model for Forecasting the Equity Premium (out-of-sample & cross-section) Monthly Data

This work does not test Fama and French (1995) model due to the limited number of stocks in the Brazilian stock market, but the Fama and French (1992, 1993), which contradicts the Sharpe-Lintner-Black CAPM model.

For the panel cointegration regressions, with three factor models, the excess equity return $R_t^i - R_t^f$ is estimated as

$$R_t^i - R_t^f = a_i + \beta_1^i \gamma_{1t}^i + \beta_2^i \gamma_{2t}^i + \beta_3^i \gamma_{3t}^i + \eta_t^i \quad (10)$$

where the panel has cross-section dimension $i = 1, \dots, N$ (number of equities) and time dimension $t = 1, 2, \dots, T$, and estimated parameters $[\hat{\beta}_1^i, \hat{\beta}_2^i, \hat{\beta}_3^i]$ that are called loading factors.

Following the same reasoning of the last section, the panel CAPM would be valid if we cannot reject the null hypothesis

$$H_0 : a_i = 0 \text{ and } \gamma_{1t}^i = E(R_t^m - R_t^f) \text{ and } \beta_2^i = \beta_3^i = 0. \quad (11)$$

The variables γ_{2t}^i and γ_{3t}^i are other risk factors such as firm size, book-to-market value, leverage etc. Under the following conditions: $\gamma_{1t}^i = R_t^m - R_t^f$, γ_{2t}^i is the firm size; γ_{3t}^i is profile, we have, as a particular case of equation (three-factors), the panel version of the Fama-French three-factor model (1992, 1993).

Table 3⁷ presents twenty and one alternative models in terms of panel cointegration regarding the FMOLS (fully modified OLS) estimator. All explanatory variables are significant. In this sense, the possible explanatory variables for the stock premium can be: (i) the market premium; (ii) the square of market premium (non-linear model); (iii) the firm size; (iv) the equity profile; (v) the equity price-earnings ratio; and (vi) the dividend yield. Nevertheless, Fama and French (1992) point out that the variables, such as, size, price-earnings' ratio, leverage and book-to-market (profile) are all scaled versions of the firm's stock price. As we have noted before, the coefficients for firm size are negative, and the coefficients for the profile effect are positive, that is, large companies will underperform small companies returns, and growth companies will overperform value companies, as we would expect. Nevertheless, interpretation of the P/E coefficient is controversial, since we have both positive and negative regression coefficients. *A priori*, we would expect a positive coefficient, but further questions should be addressed, such as the quality of earnings and the credibility of accounting practices used to produce financial reports. If investors have reasons to believe that trailing earnings are not important for predicting future earnings, then the regression coefficients could have a negative effect on return. From table 3, we can verify that when P/E is used alone or jointly with the market excess return, whether or not squared, it has a negative effect, but when it is used jointly with firm size or profile it has a positive effect. One possible reason for the mixing sign for the coefficient of the P/E is that firm size and profile may help investors to identify companies that adopt best accounting practices, turning P/E a more meaningful indicator of future performance.

Which model should be selected? What would be an acceptable criterion? We use the best-fit criterion in terms of squared sum of forecasting errors for the cross-section equity premiums

Table 3
Panel Cointegration Explanatory Variables for the Equity Premium. Monthly Data

<i>Estimator</i>	<i>Explanatory variables: Financial variables only</i>						<i>Best-Fit Criteria</i>	
<i>FMOLS</i>								
<i>Dependent Variable:</i>	<i>x: Market excess return over risk-free rate</i>	<i>x²: (Market excess return over risk-free rate)²</i>	<i>Size: LnMKT</i>	<i>Stock's price-to-book value LnPVPA: Log (Stock's price/own capital per share)</i>	<i>P/E: stock's price/earnings per share</i>	<i>Dividend Yield</i>	<i>Sum Square of different in Premiums (Actual vs. Fitted)</i>	<i>Correlation Premiums (Actual vs. Fitted)</i>
Model 1	0.74 (3.90)						0.05	0.20
Model 2		4.39 (4.03)					2.07	0.55
Model 3	0.20 (4.55)	3.32 (5.27)					7.23	-0.07
Model 4			-0.033 (-2.83)				27	0.24
Model 5	0.70 (3.30)		-0.012 (-2.90)				157	-0.06
Model 6				0.011 (3.7)			0.02	0.42
Model 7	0.72 (5.46)			0.012 (3.6)			0.26	0.22
Model 8					-0.002 (-293)		0.05	0.35
Model 9	0.69 (3.37)				-1.00E-04 (-3.13)		0.06	0.33
Model 10						-0.066 (-5.48)	0.11	0.23
Model 11	0.70 (4.07)					-0.167 (- 5.31)	0.00	0.88
Model 12			-0.040 (-2.42)	0.046 (2.3)			1.20	0.21
Model 13			-0.032 (-2.86)		0.0006 (3.07)		0.42	0.11
Model 14	0.23 (4.64)	2.95 (3.51)	-0.010 (-2.95)				0.01	0.87
Model 15	0.23 (3.83)	2.96 (3.5)			-1.00E-04 (-3.20)		0.01	0.58
Model 16	0.68 (4.57)		-0.007 (2.46)	0.024 (3.4)			0.00	1.00
Model 17	0.67 (3.84)		-0.014 (-294)		3.00E-04 (3.22)		204	0.31
Model 18	0.67 (3.92)		-0.011 (- 2.70)			-0.106 (-4.7)	0.69	0.67
Model 19			-0.037 (-2.47)	0.029 (3.3)	0.002 (3.07)		0.00	0.98
Model 20				0.015 (3.8)	0.001 (2.90)	0.339 (4.5)	0.00	0.97
Model 21	0.69 (3.47)			0.015 (3.54)		0.004 (4.6)	0.00	0.92

(..): t-student; N = 24 (stocks), T = 83 (number of months), max-lag = 4

(actual versus predicted). In other words, according to equation (three-factors), for the entire panel (cross-section of stocks and estimating period sample errors), the average of forecasted equity premiums is obtained using the parameters $[\hat{\beta}_1^i, \hat{\beta}_2^i, \hat{\beta}_3^i]$ estimated for the estimating period sample (1998:10-2002:12) and the average of explanatory variables $[\hat{\gamma}_{1t}^i, \hat{\gamma}_{2t}^i, \hat{\gamma}_{3t}^i]$ for the forecasting period sample (2003:01-2006:10). The results are presented in table 3, and the models are ranked both by the forecasting error criterion and by the correlations between the fitted and actual equity premiums, as reported in the last two columns of this table. Following these criteria, we attained: (i) the model 16 in table 3 (the first best model due to its correlation between the actual premium and the predicted ones equals 1.00); (ii) the model 19 (second best - correlation 0.98); and; (iii) the model 20 (3rd best- correlation 0.97). These models are illustrated in figure 4, and, since actual equity premiums lies almost exactly on the SML, then if someone uses any other different model in their investment decision process, one will be exposed to mispricing, which will eventually lead to wrong trading strategies. As a consequence, we could denominate these just proposed three-factor models as satisfying a non-arbitrage condition in the sense that no one else in the equity market will have a better price forecast than what these model can do. As a consequence, for the Brazilian equity market, these new asset pricing models have better performance than both the usual CAPM and the Fama and French (1992) three-factor model. This latter model allows is susceptible to arbitrage for portfolios with low β_i 's (the fitted value is much different from the actual data).

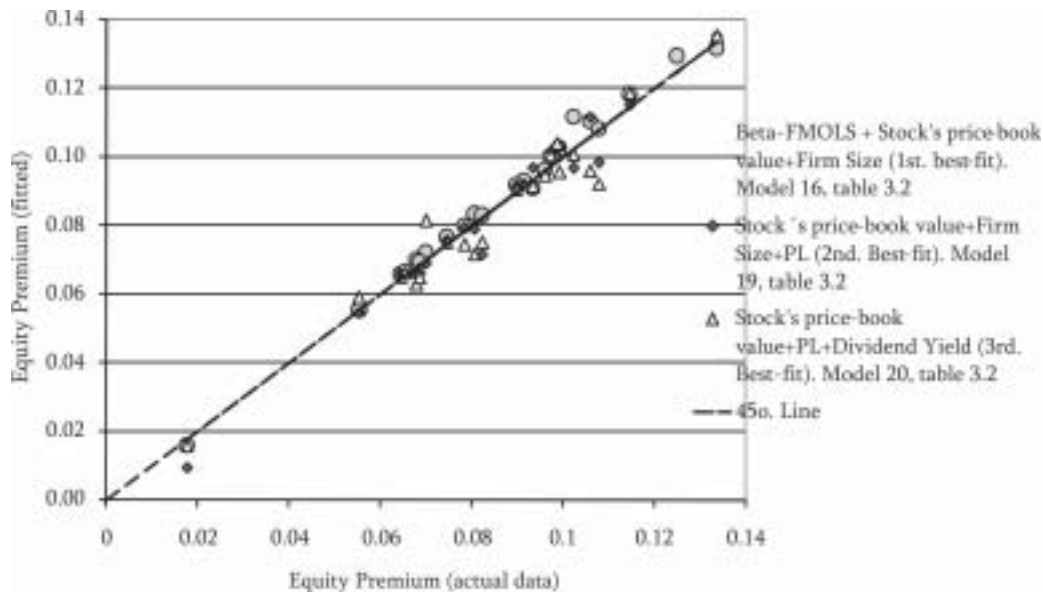


Figure 4: Three-Factor Models for Predicting the Equity Premium (out-of-sample & cross section) Monthly Data

CONCLUSIONS

This paper tests the CAPM for the Brazilian equity market using the recent panel cointegration technique, specifically, the FMOLS (fully modified OLS) estimator. This approach is quite useful for emergent markets where there are a limited number of listed companies in the stock exchanges. Black-Jensen-Scholes or Fama-MacBeth approach of composing selected portfolios is only possible for more developed markets where thousands of equities are traded.

Our main conclusion is that the Brazilian CAPM is dead for two reasons. First, the intercept for the security market line is not zero. Second, we find other possible relevant explanatory variables for the panel stock premium: (i) the market premium; (ii) the square of the market premium (non-linear CAPM); (iii) the firm size; (iv) the equity profile; (v) the equity price-earnings ratio; and (vi) the dividend yield. Given these candidates, we may describe the non-arbitrage condition as the model having its square sum of forecasting errors of actual versus the predicted premium equals zero. The three models that approximate the non-arbitrage condition most are:

- (i) The first best-model (correlation 1.00 between the actual and predicted premiums) has the following risk factors: a) beta; b) equity profile, and c) firm size. Although this model reveals some similarities with the model proposed by Fama and French (1992), their model does not satisfy the non-arbitrage condition for the Brazilian equity market. The key difference between Fama and French (1992) and this model is how to calculate the explanatory variables (firm size and stock profile) and how the model parameters were estimated. We used the FMOLS estimator whereas Fama and French (1992) used a two-stage OLS procedure (time series dimension in the first-stage and cross-section dimension for the security market line in the second-stage);
- (ii) The second best-model (correlation 0.99 between actual and fitted premiums) is composed of: (a) stock profile; (b) firm size; and (c) equity price-earnings ratio;
- (iii) The third best model (correlation 0.97) has the explanatory variables: (a) equity profile; (b) equity price-earnings ratio; and (c) dividend yield. Note that, there is no market premium as an explanatory variable in the last two models.

For further developments, we suggest to check the Fama and French (1992) three-factor model for the NYSE, but using the recent panel cointegration technique suggested in this paper, instead of the usual two-stage OLS procedure.

In summary, besides the Fama and French (1992) three-factor model, we found two additional three-factor models without the market premium as the first factor. Furthermore, our three-factor models are closest to absence of arbitrage. As pointed before, the non-arbitrage condition is violated by Fama-French model for portfolios with low β_i 's. Finally, the CAPM is also dead for the Brazilian equity market due to other factors that, in concurrence, explain better the equity premium. Therefore, the new alternative factor models better provide both pricing and trading strategies for the Brazilian stock market.

Table 4

<i>Number of stocks</i>	<i>Stock code</i>	<i>Company</i>	<i>Weight in the Index^(*)</i>
1	TNLP4	Telemar PN	8.41
2	PETR4	Petrobrás PN	7.97
3	VALE5	Vale do Rio Doce PNA	7.08
4	USIM5	Usiminas PNA	5.99
5	CSNA3	Sid. Nacional ON	4.41
6	GGBR4	Gerdau PN	4.19
7	CMET4	CAEMI PN	3.83
8	ELET6	Elektrobras PNb	3.28
9	BBDC4	Bradesco PN	3.21
10	ITAU4	Itaubanco PN	2.50
11	EBTP4	Embratel PN	2.29
12	TSPP4	Brasil Telec PN	2.27
13	ITSA4	Itausa PN	1.45
14	AMBV4	AMBEV PN	1.43
15	CSTB4	Sid. Tubarão PN	1.40
16	VCPA4	VCP PN	1.39
17	UBBR11	Unibanco UNT	1.26
18	GOAU4	Gerdau Met PN	1.19
19	SDIA4	SADIA PN	1.15
20	TCSL4	TIM Part PN	1.10
21	ACES4	ACESITA PN	1.06
22	ARCZ6	Aracruz PNB	1.06
23	EMBR4	Embraer PN	1.04
24	B RTP4	Brasil T Par PN	1.00

(*) Valid for Sept. 2005.

Table 5
Panel Unit Root Tests, Brazil: 1998: 10-2006-10

<i>Unit Root Tests</i>	<i>Equity premium</i>	<i>Market premium</i>	<i>LnMKT: Log [stock's price* shares outstanding]</i>	<i>PE: stock's price/earnings per share</i>	<i>Dividend yield</i>
Levin-Lin rho-statistic	5.60	3.00	3.20	2.86	1.75
Levin-Lin t-rho-statistic	1.78	2.17	1.94	2.45	2.54
Levin-Lin ADF-statistic	1.29	1.54	1.65	1.83	1.57
IPS ADF-statistic	1.52	1.47	1.40	2.00	2.21

N = 24 , T = 83, hetero trends, subtracted time mean.

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