Methodology of Econometrics

1. Statement of theory or hypothesis
2. Specification of mathematical model of the theory
3. Specification of econometric model of theory
4. Obtaining the data
5. Estimation of the parameters of the econometric model
6. Hypothesis testing
7. Forecasting or prediction
8. Using model for control or policy purposes

Capital Asset Pricing Model (CAPM)

BETA: Key Statistics for BETA OIL & GAS - Yahoo! Finance - Microsoft Internet Explorer

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Data provided by Reuters, except where noted.

VALUATION MEASURES	
Market Cap (intraday):	53.07M
Enterprise Value (9-May-04)³:	64.49M
Trailing P/E (ttm, intraday):	101.67
Forward P/E (fye 31-Dec-05)¹:	0.00
PEG Ratio (5 yr expected)¹:	N/A
Price/Sales (ttm):	3.94
Price/Book (mrq):	1.74
Enterprise Value/Revenue (ttm)³:	4.99
Enterprise Value/EBITDA (ttm)³:	10.15

FINANCIAL HIGHLIGHTS	
Fiscal Year	
Fiscal Year Ends:	31-Dec
Most Recent Quarter (mrq):	31-Dec-03
Profitability	
Profit Margin (ttm):	7.47%
Operating Margin (ttm):	11.57%
Management Effectiveness	
Return on Assets (ttm):	2.14%
Return on Equity (ttm):	1.80%

TRADING INFORMATION	
Stock Price History	
Beta:	1.372
52-Week Change:	310.58%
52-Week Change (relative to S&P500):	248.81%
52-Week High (7-May-04):	4.48
52-Week Low (14-May-03):	0.81
50-Day Moving Average:	3.28

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Meaning of BETA vs S&P500

BETA	Volatility in % Vs. S&P500	DESCRIPTION
2.50	150%	A Beta coefficient of 2.50 represents stock price movement that tends to be **150% more volatile** than the S&P 500 Index.
1.00	0%	A Beta coefficient of 1.00 represents stock price movement that tends to have the **same volatility** as the S&P 500 Index.
0.50	50%	A Beta coefficient of 0.50 represents stock price movement that tends to be **half as volatile** as the S&P 500 Index.
-0.50	50%	A Beta coefficient of -0.50 represents stock price movement that tends to be **half as volatile** of the S&P 500 Index, but one whose **price tends to move in the opposite direction**.
-1.00	0%	A Beta coefficient of -1.00 represents stock price movement that tends to have the **same volatility** as the S&P 500 Index, but one whose **price tends to move in the opposite direction**.

Capital Asset Pricing Model (CAPM)

An Application of Bivariate Regression Analysis

Theoretical Concept

The rate of return on an investment:

$$r \equiv \frac{p_1 + d - p_0}{p_0}$$

where:

p_1 = price of security at the end of the time period.

d = dividends (if any) paid during the time period.

p_0 = price of security at the beginning of the time period.

Capital Asset Pricing Model

An Application of Bivariate Regression Analysis

<u>Risk Premium</u>

$$Risk \;\; premium \equiv r_j - r_f$$

where

r_j = Rate of return on j^{th} asset.

r_f = Risk-free Rate of Return.

Diversification & Portfolio Optimality

Markowitz (1959) explain that investors can diversify their investment risk by holding portfolio

If investor holds two securities, the expected return on the total portfolio is

$$r_p = w_1 r_1 + w_2 r_2$$

where

r_p = Expected return on the total portfolio

w_j = Proportion of total funds invested in asset *j*, & *j* = *1, 2.*

r_j = Rate of return on asset *j*, & *j* = *1, 2.*

Diversification & Portfolio Optimality

If investor holds portfolio of n securities, return on the total portfolio can be defined as:

$$r_p = \sum_{j=1}^{n} w_j r_j$$

Variance of the total portfolio is:

$$\sigma_p^2 = \sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \sigma_{ij} = \sum_{i=1}^{n} w_i^2 \sigma_i^2 + 2\sum_{i=1}^{n}\sum_{j=i+1}^{n} w_i w_j \sigma_{ij}$$

Relationship between Risk and Return

Sharpe (1964) & Lintner (1965) claimed that if investor holds a portfolio, called *a*, and the risk-free asset, return of the new portfolio equals: $r_p = (1 - w_a) r_f + w_a r_a$

where w_a is the proportion of total funds invested in portfolio a.

Variance of the new portfolio is:

$$\sigma_p^2 = w_a^2 \sigma_a^2 + (1 - w_a)^2 \sigma_f^2 + 2 w_a (1 - w_a) \sigma_{af}$$

where σ_{af} is covariance of expected return of portfolio a and that on the risk-free asset.

Relationship between Risk and Return

According to its definition, risk-free asset is asset without risk or the variance of return on risk-free asset σ_f^2 is equal to 0. Therefore,

$$\sigma_p^2 = w_a^2 \sigma_a^2 \qquad or \qquad \sigma_p = w_a \sigma_a$$

Then $\quad w_a = \sigma_p / \sigma_a \quad$ and $\quad (1 - w_a) = 1 - \sigma_p / \sigma_a$

Expected return of portfolio can be rewritten as:

$$r_p = r_f + \left[\frac{r_a - r_f}{\sigma_a} \right] \sigma_p$$

Relationship between Risk and Return

Linear relationship between risk σ_p and return r_p

$$r_p = r_f + \left[\frac{r_a - r_f}{\sigma_a}\right]\sigma_p = r_f + \gamma\sigma_p$$

If investor invests mainly on security j, together with portfolio a, which reflects the overall security market, e.g., SET Index.

Then, we substitute r_p with r_j ; r_a with r_m ; σ_p with σ_j ; and σ_a with σ_m

$$r_j - r_f = \left(\sigma_j / \sigma_m\right)\left(r_m - r_f\right)$$

Econometrics Model for CAPM

We can derive CAPM as an econometric model:

$$r_j - r_f = \underbrace{\left(\sigma_j / \sigma_m\right)}\left(r_m - r_f\right)$$

$$\underbrace{r_j - r_f}_{Y} = \beta \underbrace{\left(r_m - r_f\right)}_{X} + u$$

$$Y = \beta X + u$$

According to original CAPM, the regression model is regression through the origin or model without intercept term.

Econometrics Model for CAPM

Jensen (1968) identified the existence of risk premium of portfolio or Jensen's Alpha:

$$r_j - r_f = \alpha_j + \beta\left(r_m - r_f\right) + u$$

$$Y = \alpha_j + \beta X + u$$

In this model, β represents relationship of risk-premium of security j and risk-premium of market portfolio. We call this index as Investment Beta.

According to original CAPM, value of α_j should be 0. However, empirical evidences have found the significant α_j.

Econometrics Model for Arbitrage Pricing Theory (APT)

Ross (1976) expanded concept of the CAPM by adding major economic variables into the model. The CAPM changes from simple regression to be multiple regression model.

$$r_j - r_f = \alpha_j + \beta_j \left(r_m - r_f \right) + \sum_{i=1}^{n} \gamma_i x_i + u$$

where x_i is major economic variables $i = 1, 2, \dots n.$ e.g. interest rate, inflation rate.

Econometrics Model for Fama & French Three-Factor Model

Fama & French (1993) argued that return on portfolio in excess of risk free rate is explained by three factors:

1. Excess return on market portfolio
2. Difference between return on portfolio of small stocks and return on portfolio of large stocks (SMB, small minus big)
3. Difference between return on portfolio of high-book-to-market stocks and return on portfolio of low-book-to market stocks (HML, high minus low).

Econometrics Model for Fama & French Three-Factor Model

Fama & French Three-factor model:

$$\left(r_j - r_f\right)_t = \alpha_j + \beta_{mj}\left(r_m - r_f\right)_t + \beta_{sj} SMB_t + \beta_{hj} HML_t + u_t$$

where

SMB is the difference between return on small size stocks portfolio and return on large stocks portfolio.

HML is the difference between return on high growth stocks portfolio and low growth stocks portfolio.

Econometrics Model for Fama & French Three-Factor Model

Fama & French Three-factor model:

$$\left(r_j - r_f\right)_t = \alpha_j + \beta_{mj}\left(r_m - r_f\right)_t + \beta_{sj} SMB_t + \beta_{hj} HML_t + u_t$$

where

β_{mj} represents market risk premium.

β_{sj} represents size premium.

β_{hj} represents growth premium.

Econometric Analysis of CAPM vs Fama & French Three-Factor Model

To test whether CAPM or Fama & French Three-factor model is more appropriated, restricted-unrestricted F-test can be applied.

$$\boxed{H_0: \quad \beta_{sj} = \beta_{hj} = 0}$$

UR: $\left(r_j - r_f\right)_t = \alpha_j + \beta_{mj}\left(r_m - r_f\right)_t + \beta_{sj} SMB_t + \beta_{hj} HML_t + u_t$

R: $\left(r_j - r_f\right)_t = \alpha_j + \beta_{mj}\left(r_m - r_f\right)_t + u_t$

$$F = \frac{\left(RSS_R - RSS_{UR}\right)/m}{RSS_{UR}/(n-k)}$$

Dummy Variable

In the case that we have special event that cannot be quantify (i.e. economics crisis), dummy variable can be used.

Dummy variable is a discrete and binary-choice variable (0 or 1) that used to quantify qualitative independent variable.

Dummy variable can only be 0 or 1. It cannot be 1 or 2.

In case that qualitative variable has more than 2 choices, the model will have more than 1 dummy variable.

(Two choice – 1 dummy), (Three choice – 2 dummy), (Four choice – 3 dummy).

Intercept Dummy Variable

General model $Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + u_t$

Model with Intercept Dummy Variable

$$Y_t = \beta_0 + \gamma_0 D_t + \beta_1 X_{1t} + \beta_2 X_{2t} + u_t$$

where: $D_t = 0$ before crisis
$= 1$ after crisis.

This model can be interpreted as:

Before Crisis: $Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + u_t$

After Crisis: $Y_t = (\beta_0 + \gamma_0) + \beta_1 X_{1t} + \beta_2 X_{2t} + u_t$

Intercept & Slope Dummy Variables

Model with Intercept and Slope Dummy Variable

$$Y_t = \beta_0 + \gamma_0 D_t + \beta_1 X_{1t} + \gamma_1 D_t X_{1t} + \beta_2 X_{2t} + \gamma_2 D_t X_{2t} + u_t$$

where: $D_t = 0$ before crisis
$= 1$ after crisis.

This model can be interpreted as:

Before Crisis: $Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + u_t$

After Crisis: $Y_t = (\beta_0 + \gamma_0) + (\beta_1 + \gamma_1) X_{1t} + (\beta_2 + \gamma_2) X_{2t} + u_t$

Test Structural Change – Dummy Variable Test vs Chow Test

Dummy Variable Technique

R

All $$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + u_t$$

UR

Before $$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + u_t$$

After $$Y_t = (\beta_0 + \gamma_0) + (\beta_1 + \gamma_1) X_{1t} + (\beta_2 + \gamma_2) X_{2t} + u_t$$

Chow Test

1

All $$Y_t = \lambda_0 + \lambda_1 X_{1t} + \lambda_2 X_{2t} + u_t \qquad \text{for } t = 1, 2, \ldots, n_1 + n_2$$

2

Before $$Y_t = \alpha_0 + \alpha_1 X_{1t} + \alpha_2 X_{2t} + u_{1t} \qquad \text{for } t = 1, 2, \ldots, n_1$$

3

After $$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + u_{2t} \qquad \text{for } t = n_1+1, n_1+2, \ldots, n_1+n_2$$

Dummy Variable vs Chow Test

Chow Test

$$H_0: \quad \alpha_0 = \beta_0 = \lambda_0 \quad and \quad \alpha_1 = \beta_1 = \lambda_1 \quad and \quad \alpha_2 = \beta_2 = \lambda_2$$

$$H_a: \quad Otherwise$$

$$F = \frac{(RSS_1 - RSS_2 - RSS_3)/k}{(RSS_2 + RSS_3)/(n_1 + n_2 - 2k)}$$

Dummy Variable

$$H_0: \quad \gamma_0 = \gamma_1 = \gamma_2 = 0$$

$$H_a: \quad Otherwise$$

$$F = \frac{(RSS_R - RSS_{UR})/k}{RSS_{UR}/(n-k)}$$

Comparing the Two Methods

Chow test is to test whether all estimators are the same or not.

Dummy variables technique test whether intercept dummy coefficient and all slope dummy coefficients are all equal to zero or not.

Interaction Effects Using Dummy Variables

Model with Intercept and Interaction Dummy Variables

$$Y_t = \alpha_0 + \alpha_1 D_{Mt} + \alpha_2 D_{Jt} + \alpha_3 D_{Mt} D_{Jt} + \beta X_t + u_t$$

where: $D_{Mt} = 0$ other days or $= 1$ Monday.
$D_{Jt} = 0$ other months or $= 1$ January.

The coefficients of the dummy variables can be interpreted as:

α_1 = Monday effect.
α_2 = January effect.
α_3 = Monday in January effect.