SHANGHAI JIAO TONG UNIVERSITY

THE REPORT FOR THE TEAM PROJECT OF BUSSINESS COMPUTING

TITLE: THE TIME-VARYING PROCESS OF THE BETA COEFFICIENT

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THE TIME-VARYING PROCESS OF THE BETA COEFFICIENT

ABSTRACT

With the rapid development of our capital market, risks in the related market are becoming higher and higher. As a consequence, the research about the risk of securities in the capital market has been much increasingly important. The unsystematic risks of securities in capital asset markets can be dispelled through combination investment. The others labeled as systematical risks, which are hard to dispel, can be represented in the term of beta coefficient(β). Since the beta coefficient estimates the systematical risks of securities in the future, its precise value is hard to determine. However, when investors can grasp the time-varying process of beta coefficient, the systemic risk factor, they can have a good command of the risk of securities on the capital assets market and then make a better investment. When the management can master the risk of securities on the capital assets market, they will be able to understand any potential threat confronted by their companies. Therefore, the main problem we are going to solve is the time-varying problem of beta coefficient when investors have a single investment period.

Key words: beta coefficient, CAPM model, the time-varying process, programming

CONTEXT

Chapter 1. Background of beta

1.1. Definition of beta coefficient

The beta (β or beta coefficient) of an investment is a measure of the volatility, or systematic risk, of a security or a portfolio in comparison to the market as a whole.It indicates whether the investment is more or less volatile than the market as a whole. Beta is
used in the capital asset pricing model (CAPM), which calculates the expected return of an asset based on its beta and expected market returns.

Beta is important because it measures the risk of an investment that cannot be reduced by diversification. It does not measure the risk of an investment held on a stand-alone basis, but the amount of risk the investment adds to an already-diversified portfolio.

1.2. The Value of Beta

The market portfolio of all investable assets has a beta of exactly 1.
A beta more than 1 indicates that the investment is more volatile than the market and the asset tends to move up and down with the market. An example is a stock in a big technology company.

A beta below 1 and above 0 can indicate either an investment with lower volatility than the market, or a volatile investment whose price movements are not highly correlated with the market. An example is a treasury bill: the price does not go up or down a lot, so it has a low beta. Another example is gold. The price of gold does go up and down a lot, but not in the same direction or at the same time as the market.

Negative betas are possible for investments that tend to go down when the market goes up, and vice versa. There are few fundamental investments with consistent and significant negative betas, but some derivatives(衍生品) like put options can have large negative betas.

Table 1-2 : Summary of beta

Value of Beta	**Interpretation**	**Example**
$\beta < 0$	Asset movement is in the opposite direction of the benchmark	An inverse exchange-traded fund or a short position
$\beta = 0$	Asset movement is uncorrelated to the benchmark	Fixed-yield asset, whose growth is unrelated to the movement of the stock market
$0 < \beta < 1$	Asset moves in the same direction, but in a lesser amount than the benchmark	Stable, "staple" stock such as a company that makes soap. Moves in the same direction as the market at large, but less susceptible to day-to-day fluctuation.
$\beta = 1$	Asset moves in the same direction	A representative stock, or a stock that is a strong

	and in the same amount as the benchmark	contributor to the index itself.
$\beta > 1$	Asset moves in the same direction, but in a greater amount than the benchmark	Stocks which are very strongly influenced by day-to-day market news, or by the general health of the economy.

Chapter 2. The capital asset pricing model (CAPM)

2.1. The definition of CAPM model

In finance, the capital asset pricing model (CAPM) is a model used to determine a theoretically appropriate required rate of return of an asset, to make decisions about adding assets to a well-diversified portfolio.

2.2. The application of CAPM model

For individual securities, we make use of the security market line (SML) and its relation to expected return and systematic risk (beta) to show how the market must price individual securities in relation to their security risk class. The SML enables us to calculate the reward-to-risk ratio for any security in relation to that of the overall market. Therefore, when the expected rate of return for any security is deflated by its beta coefficient, the reward-to-risk ratio for any individual security in the market is equal to the market reward-to-risk ratio.

2.3. The calculating principle of CAPM

The market reward-to-risk ratio is effectively the market risk premium and by rearranging the above equation and solving for E(Rj) we obtain the capital asset pricing model (CAPM).

$$E_{R_j} = R_f + \beta \times (E_{R_m} - R_f) \qquad (2\text{-}3)$$

E(Rj) : is the expected return on the capital asset
Rf : is the risk-free rate of interest such as interest arising from government bonds
E(Rm) : is the expected return of the market
E(Rm)-Rf : the market premium

Note 1: the expected market rate of return is usually estimated by measuring the arithmetic average of the historical returns on a market portfolio (e.g. S&P 500).

Note 2: the risk free rate of return used for determining the risk premium is usually the arithmetic average of historical risk free rates of return and not the current risk free rate of return.

Chapter 3. CSI300

3.1. The definition of CSI300

The CSI 300 is a capitalization-weighted stock market index designed to replicate the performance of 300 stocks traded in the Shanghai and Shenzhen stock exchanges.

It has been calculated since April 8, 2005. Its value is normalized relative to a base of 1000 on December 31, 2004.

3.2. Examples for Sub-Indicies

CSI 300 Energy Index
CSI 300 Materials Index
CSI 300 Industrials Index
CSI 300 Consumer Discretionary Index
CSI 300 Consumer Staples Index
CSI 300 Health Care Index
CSI 300 Financial Index
CSI 300 Information Technology Index
CSI 300 Telecommunications Index
CSI 300 Utilities Index

Chapter 4. The python program

4.1. The fluctuation of the price of a single stock

4.1.1. Preparation

We import packages for the following calculation and graphing.

Code:
```
# insert statistics from csv file
    import pandas as pd
    import numpy as np
    import matplotlib.pyplot as plt
# for the following calculation
    import math
```

4.1.2. Read data locally

To get data of time and closing prices of the stock.

Code:
```
# parse_dates=[0]
# index_col=0
```

```
stock=pd.read_csv
('/Users/Administrator/Desktop/code/600
519.csv',parse_dates=[0], index_col=0)
```

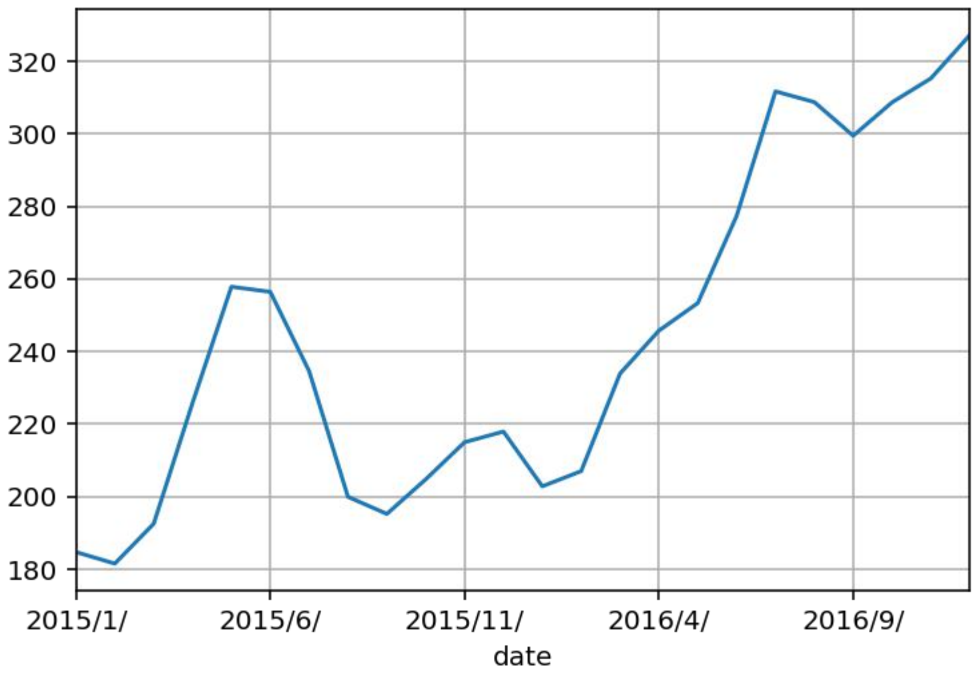
4.1.3. Graph the line chart(1)

To graph a line chart whose X axis is time and Y axis is the closing prices of the stock. In this project, we choose “Kweichow Moutai Company” as an example.

Code:

```
stock['close'].plot(grid=True)
```

Figure 4-1-3 : The fluctuation of the stock prices



4.1.4. Calculate the expected return

The formula we use in calculating the expected rate is:

$$R_k = In(P_t) - In(P_{t-1}) \qquad (4\text{-}1\text{-}4)$$

R_k means the expected rate of return,

P_t means the closing price of time t,

P_{t-1} means the closing price of time t-1.

Code:

```
#define a new column for the closing price of stock
    close_price = stock['close']
#calculate the expected rate of return
    stock["expected"] = np.log(close_price) - np.log(close_price.shift(1))
```

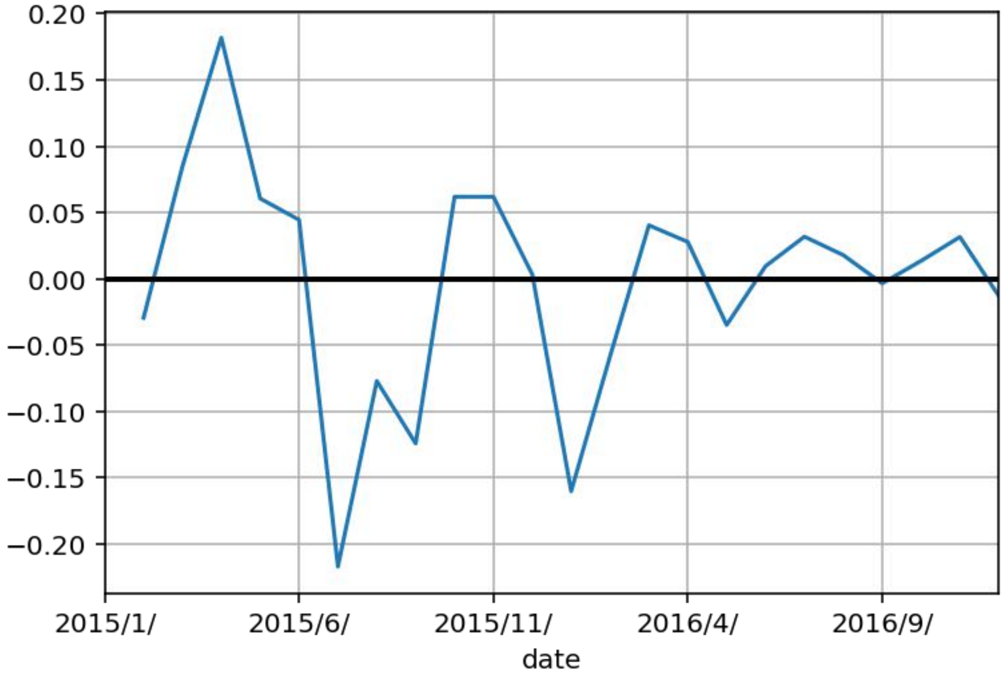
4.1.5. Graphing the line chart(2)

To graph the line chart: X axis is time and Y axis is the expected rate of return R_k.

Code:

```
stock["expected"].plot(grid=True).axhline(y=0, color='black', lw=2)
```

Figure 4-1-5 : The fluctuation of the expected rate of return



4. 2. The fluctuation of the price of market portfolio

4.2.1. Read data locally

To get data of time and closing prices of the market portfolio.

Code: *#parse_dates=[0]*

#index_col=0

```
market=pd.read_csv
('/Users/Administrator/Desktop/code/portfolio30
0.csv',parse_dates=[0], index_col=0)
```

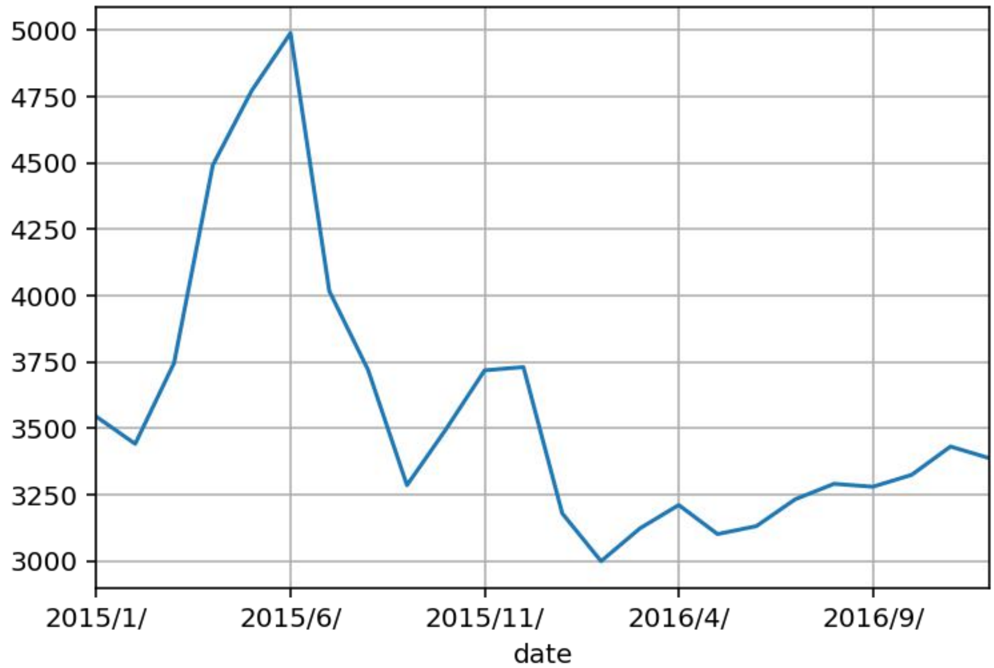
4.2.2. Graph the line chart(1)

To graph a line chart whose X axis is time and Y axis is the closing prices of the market portfolio. In our project, the data we used as closing prices of market portfolio is CSI300 index, which reflects the overall trend of the stock market in Shanghai and Shenzhen.

Code:

```
market['close'].plot(grid=True)
```

Figure 4-2-2 : The fluctuation of the market portfolio prices



4.2.3. Calculate the expected return

The formula we use in calculating the expected rate is:

$$R_m = \frac{P_t}{P_{t-1}} - 1 \qquad (4\text{-}2\text{-}3)$$

R_m means the market rate of return,

P_t means the closing price of time t

P_{t-1} means the closing price of time t-1.

Code: *#define a new column for the closing price of market portfolio*

```
close_price_market = market['close']
```

#calculate the expected rate of return

```
market['expected'] = close_price_market - close_price_market.shift(1)
```

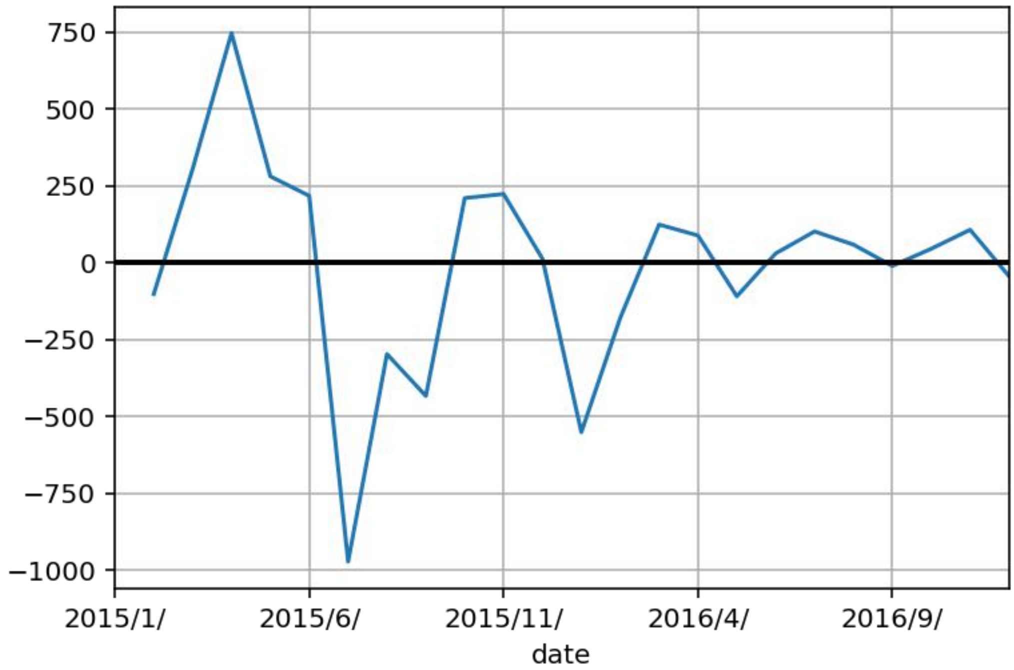
4.2.4. Graphing the line chart(2)

To graph the line chart: X axis is time and Y axis is the expected rate of return R_m

Code:

```
market['expected'].plot(grid=True).axhline(y=0, color='black', lw=2)
```

Figure 4-2-4 : The fluctuation of the expected rate of return



4. 3. The risk-free rate of return(Rf)

The risk-free rate of return is the rate at which the funds are invested in an investment target without any risk. In this project, we regard the fixed deposit profit margin of the People's Bank of China (1.1%) as the risk-free rate of return.

4. 4. The value of Beta Coefficient

4.4.1. The time-varying process of beta

Code:
```
#define a function according to the Capital Asset Pricing Model
#Using the formula (2-3)
    def beta(rk,rm):
        return (rk - 0.011)/(rm - 0.011)
    market['beta']=beta(stock["expected"],market['expected'])

#graph a line chart whose X axis is time and Y axis is β
    market['beta'].plot(grid=True).axhline(y=0, color='black', lw=2)
```

Figure 4-4 : The time-varying process of beta

4.4.2. The maximum and the minimum of beta

we can find the maximal value and minimum value of beta in the period we study using [max] and [min] function.

Code: #find the maximum of β

```
market['beta'].max()
```

#find the minimum of β

```
market['beta'].min()
```

Chapter 5. Conclusion

With the help of the convenient and intuitive interface of python, we can find that β coefficient is time changeable. Through the one-month team project, not only did we consolidate our knowledge about programming with python, but we have also learned how to apply the computing expertise to practice, for instance, financial management.

Of course, we would like to extend our sincere gratitude to our tutor, Mr. Bao, whose profound knowledge of computing and his personal charisma trigger our love for this beautiful language and whose earnest attitude tells us how to learn Python.