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Financial portfolio selection using the multifactor capital asset pricing model and imported options data

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Abstract. Diversification and portfolio selection are integral parts of a finance curriculum. In this article, a multifactor capital asset pricing model is fit for components of the Dow Jones Composite Index using data from Yahoo! Finance. Along with the capital asset pricing model's Beta, other statistics that are common criteria for portfolio selection are calculated: historic standard deviation (total risk), total return, average daily return, and Sharpe and Treynor measures. Two new commands are introduced, `fetchcomponents` and `fetchportfolio`, that automate the entire process. A third new command, `fetchyahoooptions`, is provided to download and parse equity options data from Yahoo! Finance webpages and, optionally, to calculate the implied volatilities for the downloaded options.

Keywords: dm0070, `fetchcomponents`, `fetchportfolio`, `fetchyahoooptions`, finance, financial data, multifactor capital asset pricing model, Beta, diversification, portfolio selection, Sharpe, Treynor, options, implied volatility

1 Introduction

Diversification, portfolio selection, hedging, and the capital asset pricing model (CAPM) (Sharpe 1964; Lintner 1965) are integral parts of an undergraduate and a graduate finance curriculum. Most textbooks provide detailed explanations about how to diversify, how to evaluate different financial securities, and how to fit a CAPM. Considering the importance of “learning by doing” or a “hands-on” approach, financial calculations and CAPM estimations are performed in classrooms and given as assignments. There are abundant resources about these financial calculations and CAPM estimations mostly using Microsoft Excel. However, there seem to be limited resources for students to do financial calculations and CAPM estimations using an econometric software such as Stata. Considering the speed and ease of repeatability of Stata, this is a drawback in the finance curriculum: teaching should focus more on theory and interpretation of results than on long and tiresome steps of calculations and estimations.

Microsoft Excel is one of the primary software in the industry and an asset for finance students, who should be able to use it to fit a CAPM and other financial calculations. However, automated tasks such as fitting a CAPM for multiple stocks would require them to learn either Excel macro programming or some type of econometric software.

Recently, Stata has become the popular choice of academics and students, perhaps because of its user friendliness and abundant resources.

This article is of interest to finance instructors, students, and investors.¹ It entails lecture notes to teach different criteria for portfolio selection, diversification, and options. It shows how some of the most common statistics are calculated. It provides fast and easy commands to repeat these tasks during a study session or a lecture using Stata. It enables finance instructors to assign projects using real-life data and to spend time on interpretations and on methods proportional to their importance. The provided procedures are also useful for investors (for educational purposes): using real financial data, they can compare their investment choices to achieve portfolio objectives.

The initial step is to obtain a list of stocks that make up the Dow Jones Composite Index. For this task, a new Stata command is used: **fetchcomponents**. The second step is to download historic prices for these stocks using the Stata command **fetchyahooquotes** (Dicle and Levendis 2011). Using the same command, I download Fama–French factors to fit a multifactor CAPM (Fama and French 1992, 1993). The third step is to calculate the average daily returns, total returns, standard deviation of daily returns, Sharpe (1970) measure, and Treynor (1965) measure. In this step, multifactor CAPM following Fama and French (1992, 1993) is also estimated for each stock. Another new Stata command is used to automate this process: **fetchportfolio**. The fourth step is to interpret the results. The final step is to introduce the idea of hedging portfolio risk by using **fetchyahooptions** to download options data for a few stocks. Their implied volatilities are calculated and graphed.

2 Components of Dow Jones Composite Index

A list of stocks that make up the Dow Jones Composite Index (DJA) is provided by Yahoo! Finance.² A new command, **fetchcomponents**, downloads this list to a Stata variable that contains the ticker symbols.

1. This article and associated Stata codes are for educational use. There is no direct or implied financial advice. While every effort is made for accuracy and reliability, the data and the results may not be accurate or reliable.

2. Available through <http://finance.yahoo.com/q/cp?s=DJA+Components>.

```
. fetchcomponents, symbol(^DJA) page(1)
Page: 0
Page: 1
. describe
Contains data
  obs:          65
  vars:          1
  size:         260
```

variable name	storage type	display format	value label	variable label
Symbol	str4	%9s		

```
Sorted by: Symbol
Note: dataset has changed since last saved
```

2.1 Definition

`fetchcomponents` downloads the list of components for an index. A list of stocks and components is provided by Yahoo! Finance 50 at a time. Each page of 50 is defined by the option `page`.

2.2 Syntax

```
fetchcomponents, symbol(string) [page(#)]
```

2.3 Options

`symbol(string)` specifies the symbol of the index for which the user wants to download the components (that is, `^NYA`). There can be only one symbol defined, which must be an index. `symbol()` is required.

`page(#)` specifies the number of pages for the list of components (starts from zero). Because the list of components is provided in batches of 50, it may take several pages to download the entire list (that is, for `^NYA`, there are 0 to 38 pages).

3 Historic stock prices

Daily stock prices are downloaded from Yahoo! Finance.³ Daily Fama–French factors are downloaded from Kenneth R. French’s website.⁴ The Stata code for downloading and preparing the data for the study is `fetchyahooquotes`.

3. Available through <http://finance.yahoo.com/>.

4. Available through http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

```
. levelsof Symbol, local(tickers) clean
AA AEP AES ALK AXP BA BAC CAT CHRW CNP CNW CSCO CSX CVX D DAL DD DIS DUK ED EIX
> EXC EXPD FDX FE GE GMT HD HPQ IBM INTC JBHT JBLU JNJ JPM KEX KO KSU LSTR LUV
> MATX MCD MMM MRK MSFT NEE NI NSC PCG PEG PFE PG R SO T TRV UAL UNH UNP UPS
> UTX VZ WMB WMT XOM

. fetchyahoquotes `tickers`, freq(d) chg(per) start("01jan2010")
> end("31dec2011") ff3
Fama/French daily factors are downloaded from `Kenneth R. French - Data Library`.
AA is downloaded.
AEP is downloaded.
AES is downloaded.

(output omitted)

WMB is downloaded.
WMT is downloaded.
XOM is downloaded.

time variable: date, 04jan2010 to 30dec2011, but with gaps
delta: 1 day
(0 observations deleted)
(0 observations deleted)
```

```
. describe
```

Contains data from temporary_AA.dta

```
obs:      504
vars:      133                               25 Apr 2013 10:41
size:      278,208
```

variable name	storage type	display format	value label	variable label
date	double	%td		
adjclose_AA	float	%9.0g		Adj Close
per_AA	float	%9.0g		Percentage change for AA
adjclose_AEP	float	%9.0g		Adj Close
per_AEP	float	%9.0g		Percentage change for AEP
adjclose_AES	float	%9.0g		Adj Close
per_AES	float	%9.0g		Percentage change for AES
(output omitted)				
adjclose_WMB	float	%9.0g		Adj Close
per_WMB	float	%9.0g		Percentage change for WMB
adjclose_WMT	float	%9.0g		Adj Close
per_WMT	float	%9.0g		Percentage change for WMT
adjclose_XOM	float	%9.0g		Adj Close
per_XOM	float	%9.0g		Percentage change for XOM
ff3_Mkt_RF	double	%10.0g		
ff3_SMB	double	%10.0g		
ff3_HML	double	%10.0g		
ff3_RF	double	%10.0g		

Sorted by: date

Note: dataset has changed since last saved

4 Calculating financial statistics and fitting a multifactor CAPM

The formula for fitting a multifactor CAPM (Fama and French 1992, 1993) is as follows:

$$r_{i,t} - r_{f,t} = \alpha + \beta(r_{m,t} - r_{f,t}) + \gamma(SMB_t) + \theta(HML_t) + \epsilon_t \quad (1)$$

A new command, `fetchportfolio`, fits the multifactor CAPM and other financial statistics for all the stocks that constitute the DJIA. CAPM estimations are based on the daily percentage change of dividend- and split-adjusted closing prices.

```
. fetchportfolio `tickers`, year(2010 2011)
Fama/French daily factors are downloaded from `Kenneth R. French - Data Library`.
AA is downloaded.
AEP is downloaded.
AES is downloaded.
(output omitted)
WMB is downloaded.
WMT is downloaded.
XOM is downloaded.
      time variable:  date, 04jan2010 to 30dec2011, but with gaps
                   delta:  1 day
(3965 observations deleted)
(140 observations deleted)
. describe
Contains data from temp_00001_2010.dta
   obs:           64
  vars:           27
 size:          6,912
25 Apr 2013 10:49
```

variable name	storage type	display format	value label	variable label
Symbol	str4	%9s		
Beta_2010	float	%9.0g		Multifactor CAPM Beta
R2_2010	float	%9.0g		Multifactor CAPM R-squared
Sum_2010	float	%9.0g		Total return for the year (includes dividend yield).
Sd_2010	float	%9.0g		Standard deviation of daily returns for the year.
Mean_2010	float	%9.0g		Average daily return for the year.
Mean_rf_2010	float	%9.0g		Average daily return for the year minus average risk-free rate.
Dividends_2010	float	%9.0g		Dividend yield for the year.
Beta_2011	float	%9.0g		Multifactor CAPM Beta
R2_2011	float	%9.0g		Multifactor CAPM R-squared
Sum_2011	float	%9.0g		Total return for the year (includes dividend yield).
Sd_2011	float	%9.0g		Standard deviation of daily returns for the year.
Mean_2011	float	%9.0g		Average daily return for the year.
Mean_rf_2011	float	%9.0g		Average daily return for the year minus average risk-free rate.
Dividends_2011	float	%9.0g		Dividend yield for the year.
Mean_sd_2010	float	%9.0g		Mean daily return / Standard

Sharpe_2010	float	%9.0g	deviation of daily returns (Mean daily return - mean risk-free rate) / Standard deviation of daily returns
Sum_sd_2010	float	%9.0g	Total return (includes dividend yield) / Standard deviation of daily returns
Mean_Beta_2010	float	%9.0g	Mean daily return / Multifactor CAPM Beta
Treynor_2010	float	%9.0g	(Mean daily return - mean risk-free rate) / Multifactor CAPM Beta
Sum_Beta_2010	float	%9.0g	Total return (includes dividend yield) / Multifactor CAPM Beta
Mean_sd_2011	float	%9.0g	Mean daily return / Standard deviation of daily returns
Sharpe_2011	float	%9.0g	(Mean daily return - mean risk-free rate) / Standard deviation of daily returns
Sum_sd_2011	float	%9.0g	Total return (includes dividend yield) / Standard deviation of daily returns
Mean_Beta_2011	float	%9.0g	Mean daily return / Multifactor CAPM Beta
Treynor_2011	float	%9.0g	(Mean daily return - mean risk-free rate) / Multifactor CAPM Beta
Sum_Beta_2011	float	%9.0g	Total return (includes dividend yield) / Multifactor CAPM Beta

Sorted by: Symbol

Note: dataset has changed since last saved

4.1 Definition

`fetchportfolio` estimates and calculates financial statistics to compare financial securities for portfolio selection. `fetchyahooquotes` is needed for `fetchportfolio` to run.

4.2 Syntax

`fetchportfolio namelist, year(numlist)`

namelist is a list of ticker symbols for which the statistics are calculated and a CAPM is fit. Symbols are separated by spaces.

4.3 Option

`year(numlist)` is a list of years for which the statistics are calculated and a CAPM is fit. Years are separated by spaces.

5 Interpreting results

5.1 Multifactor CAPM Beta

```
. list Symbol Beta* R2*
```

	Symbol	Bet-2010	Bet-2011	R2_2010	R2_2011
1.	AA	1.405193	1.545471	.5650427	.7981184
2.	AEP	.7943012	.6373942	.5562428	.5718821
3.	AES	1.257982	1.262856	.5833274	.7186341
4.	ALK	1.468361	.9333242	.4253781	.5818244
5.	AXP	1.250965	1.164087	.6207132	.7460121

(output omitted)

61.	VZ	.6491743	.6290471	.3628424	.5334482
62.	WMB	1.230148	1.400854	.6391539	.6731739
63.	WMT	.6216294	.5254323	.3249495	.4530556
64.	XOM	.9589896	.9934663	.7284095	.7589387

The analysis is performed on the list of stocks that make up the DJA. There are a total of 65 stocks. For the purpose of compactness, results are provided for 10 of these 65 stocks. In the table above, there are two columns for each year: **Beta** and **R2**. **Beta** is the Beta estimated with (1). **R2** refers to the R -squared for the same regression. A CAPM is fit for each stock separately for 2010 and 2011. Higher Beta⁵ means higher market risk for each stock. Higher R -squared means more of the variation of daily stock returns is explained by the controlled independent variables: market risk, small-minus-big, and high-minus-low. As Beta increased from 2010 to 2011, we can conclude that the stocks' market risk increased. As R -squared increased from 2010 to 2011, we can conclude that the uncontrolled factors (that is, company-specific risks) became less important factors to explain the variation of daily returns.

5. Absolute value of the Beta.

5.2 Total return

```
. list Symbol Sum_20*
```

	Symbol	Sum_2010	Sum_2011
1.	AA	-5.674569	-43.91911
2.	AEP	13.75836	25.34019
3.	AES	-10.90641	-5.622488
4.	ALK	62.59323	29.71666
5.	AXP	8.655738	12.01655

(output omitted)

61.	VZ	21.74054	21.91481
62.	WMB	20.21237	40.64208
63.	WMT	4.188481	15.37066
64.	XOM	11.46432	18.8829

Total return is the percentage change in split- and dividend-adjusted closing prices from the first day to the last day of the period plus the dividend yield for the year. The figures are in percentages (that is, AA's return for 2010 was -5.67% , whereas it was -43.92% for 2011).

5.3 Total risk

```
. list Symbol Sd_20*
```

	Symbol	Sd_2010	Sd_2011
1.	AA	2.349188	2.711182
2.	AEP	1.045383	1.196054
3.	AES	2.305197	2.168423
4.	ALK	2.611011	2.442996
5.	AXP	2.066332	1.918625

(output omitted)

61.	VZ	1.043751	1.217522
62.	WMB	2.08644	2.435364
63.	WMT	.8757704	1.045985
64.	XOM	1.132489	1.597168

Total risk is the standard deviation of daily returns. Standard deviation of daily returns is based on the daily percentage change of dividend- and split-adjusted closing prices. It is interpreted as the combination of systemic and unsystemic risks.

5.4 Sharpe measure

```
. list Symbol Sharpe_20*
```

	Symbol	Shar-2010	Shar-2011
1.	AA	-.0001682	-.0693872
2.	AEP	.0343362	.0683895
3.	AES	-.008775	.0056541
4.	ALK	.0870246	.0578227
5.	AXP	.0226696	.0323365

(output omitted)

61.	VZ	.0560282	.0605425
62.	WMB	.0400964	.0636963
63.	WMT	.0114429	.0543649
64.	XOM	.0340558	.0504581

The formula for the Sharpe measure is as follows: $\text{Sharpe} = (\text{mean daily return} - \text{mean risk-free rate}) / \text{standard deviation of daily returns}$. Mean daily returns are based on the daily percentage change of dividend- and split-adjusted closing prices. Therefore, the higher the ratio, the higher the mean return per level of standard deviation (total risk).

5.5 Treynor measure

```
. list Symbol Treynor_20*
```

	Symbol	Trey-2010	Trey-2011
1.	AA	-.0002812	-.1217243
2.	AEP	.04519	.1283311
3.	AES	-.0160798	.0097086
4.	ALK	.1547454	.1513523
5.	AXP	.0374454	.0532964

(output omitted)

61.	VZ	.0900828	.1171802
62.	WMB	.068007	.1107351
63.	WMT	.0161211	.1082249
64.	XOM	.0402171	.0811201

The formula for the Treynor measure is as follows: Treynor = (mean daily return – mean risk-free rate)/multifactor CAPM Beta. As in the Sharpe measure, the higher the ratio, the higher the mean return for the level of Beta (market risk).

6 Importing options data

Yahoo! Finance provides free financial data for public use. While historical prices for most financial assets, as well as some important statistics, can be downloaded using Yahoo! Finance’s application programming interface,⁶ some data are only available through webpages. These important data can be accessed via web browsers. However, to access the data as Stata-usable data, one needs to parse these webpages.⁷ Stata has a powerful and fast programming language: Mata. Even though it is intended as a matrix programming language, it has hypertext transfer protocol support, regular expressions, and extensive string functions. It allows the newly introduced command **fetchyahooptions** to fetch the Yahoo! Finance options page, to parse the page, and to process its contents to make them usable as Stata data. **fetchyahooptions** also calculates implied volatility for downloaded options using Black and Scholes’s (1973) option pricing formula following (2), (3), (4), and (5).

Unlike equity prices, options data are not easily accessible for everyone as usable data. They are an important free service that Yahoo! Finance offers for public use. Options data are important for finance lecturers to use in their classes and teaching notes. They are important for researchers of financial derivatives. Although options data are only current and historical time series are not available, they can be accessed daily and stored to create a time series. Options data are also important for investors (for educational purposes). The implied volatility allows investors to have a sense of expected volatility in the market and may allow investors to predict market direction.

6.1 Syntax

```
fetchyahooptions namelist, m(string) [iv(real) ]
```

namelist specifies a list of ticker symbols for which the options are parsed and downloaded from Yahoo! Finance’s options webpage. Symbols are separated by spaces.

6.2 Options

m(*string*) specifies the month in which the options expire (that is, 2011–12). Multiple maturity months can be included (that is, 2011–12 2012–01). **m**() is required.

6. Stata commands **fetchyahoquotes** and **fetchyahokeystats** use Yahoo! Finance’s application programming interface to download historical prices and key statistics.

7. Parsing Hypertext Markup Language (HTML) pages is a common practice; some programming languages, such as PHP and Java script, provide extensive language support. There is a regular expressions parsing language that is adopted by most web programming languages.

`iv(real)` specifies the calculated implied volatility using Black and Scholes's (1973) option pricing formula (that is, `iv(0.0001)`) following (2), (3), (4), and (5). It uses a trial-and-error method to loop through levels of volatilities to calculate a call or put option price that matches the ask price. User-supplied increment is used for the loop. As the increment gets smaller, the loop will take longer. Implied volatility is calculated separately for each strike price.

$$d_1 = \frac{\ln(S_0/K) + \left\{ (r_f + \frac{\sigma^2}{2})T \right\}}{\sigma\sqrt{T}} \quad (2)$$

$$d_2 = d_1 - \sigma\sqrt{T} \quad (3)$$

$$c = S_0 N(d_1) - K e^{-r_f T} N(d_2) \quad (4)$$

$$p = K e^{-r_f T} N(-d_2) - S_0 N(-d_1) \quad (5)$$

In these equations, S_0 refers to the spot price of the underlying security, K to the strike price, r_f to the risk-free rate,⁸ σ to the standard deviation, and T to the years to maturity.

6.3 HTML source code to Stata data transformation

Yahoo! Finance⁹ provides current prices of options for individual stocks through HTML pages. `fetchyahoooptions` uses Mata to access Yahoo! Finance options pages, parse them into string variables, and turn them into usable Stata data. The following are some of the processes that `fetchyahoooptions` uses.

The following Mata function is used to get the HTML source code from the web as a string.

```
string file_get_contents (string scalar raw)
{
    fh = fopen(raw, "r")
    raw=""
    while ((line=fget(fh))!=J(0,0,"")) {
        raw=raw+line
    }
    fclose(fh)
    return (raw)
}
```

8. For the risk-free rate, `fetchyahoooptions` downloads the current `^IRX`, the 13-week U.S. Treasury Bill yield index, from Yahoo! Finance.

9. For example, <http://finance.yahoo.com/q/op?s=IBM+Options>.

The following Mata function parses the current price of the underlying asset for the option.

```

string get_price (string scalar raw, string scalar ticker)
{
    bas_pos = strpos(strlower(raw), "<span id=" + char(34) + "yfs_l10_"
+ strlower(ticker) + char(34) + ">") + strlen(ticker) + 20

    if (bas_pos<100) bas_pos = strpos(strlower(raw), "<span id=" + char(34)
+ "yfs_l84_" + strlower(ticker) + char(34) + ">") + strlen(ticker) + 20
    if (bas_pos>100) {
        output = substr (raw, bas_pos, .)
        son_pos = strpos(strlower(output), "</span>")
        output = substr (output, 1, son_pos-1)
    }
    if (bas_pos<100) output = cat("http://download.finance.yahoo.com/d/quotes.csv?s="
+ ticker + "&f=l1")
    return (output)
}

```

A check is necessary to see whether the options table exists.

```

real check_table (string scalar raw, string scalar aranan)
{
    kalan = strpos(strlower(raw), strlower(aranan))
    return (kalan)
}

```

Options data are within the HTML table. At this point, the options table needs to be parsed.

```

string get_table (string scalar raw, string scalar tag, string scalar aranan)
{
    kalan = strlower(raw)
    while (strpos(kalan, "<" + strlower(tag)) < strpos(kalan, strlower(aranan))) {
        kalan = substr (kalan, strpos(kalan, "<" + strlower(tag)) + 2
+ strlen(tag), .)
    }
    kalan = "<" + strlower(tag) + " " + kalan
    son_pos = strpos(kalan, "</" + strlower(tag))
    kalan=substr(kalan, 1, son_pos + 2 + strlen(tag))
    return (kalan)
}

```

The above functions are called in the following order.

```
void get_options (string scalar symbol, string scalar month)
{
    icerik = file_get_contents("http://finance.yahoo.com/q/op?s=" + symbol
+ "&m=" + month)
    price = get_price(icerik,symbol)
    isthere = check_table (icerik,"Strike")
    if (isthere) {
        tablo = get_table (icerik,"table","Strike")
        tablo2 = get_table2 (icerik,"table","Strike")
        bos=table_data (tablo + tablo2)
    }
    stata("gen Price = " + price)
    icerik_rf = file_get_contents("http://finance.yahoo.com/q?s=~IRX")
    price_rf = get_price(icerik_rf,"~IRX")
    stata("gen IRX = " + price_rf)
}
```

The remaining string is parsed for individual HTML tags such as <td>, <tr>,
, etc. Parsing is lengthy and can be accessed through the `fetchyahoooptions.ado` file. Parsing is not shown here to conserve space.

The entire HTML source code downloaded from Yahoo! Finance is parsed into a single string using Mata. The string table that contains the options data has HTML tag <td>, which can be used as a line break that can then be converted into a Stata observation. The following Stata code is used for this string split.

```
split myvar, parse("</td>") gen(mfd)
```

The resulting dataset contains eight variables: **Strike**, **Symbol**, **Last**, **Change**, **Bid**, **Ask**, **Volume**, and **Open_Interest**.

6.4 Using fetchyahoooptions to fetch equity options data

▷ Example

Here options data are downloaded for IBM and GOOG using `fetchyahoooptions` for the closest maturity (April 2013) and the next closest maturity (May 2013). The program will also calculate the implied volatility.

```
. fetchyahoooptions GOOG IBM, m(2013-04 2013-05 2013-06) iv(0.0001)
Options data for GOOG (2013-04) are downloaded.
Options data for GOOG (2013-05) are downloaded.
Options data for GOOG (2013-06) are downloaded.
Options data for IBM (2013-04) are downloaded.
Options data for IBM (2013-05) are downloaded.
Options data for IBM (2013-06) are downloaded.
```



```
. twoway (line IV Strike) if (Type=="Call") & (Underlying=="GOOG") &
> (Maturity==date("22jun2013","DMY"))
```

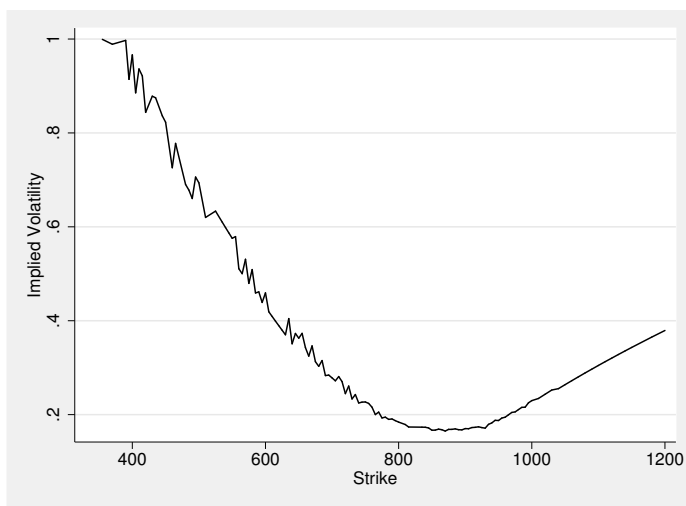


Figure 1. Implied volatility for each strike price

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