Pairs Trading

MGMT 638: Data-Driven Investments: Equity

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Overview

- Find stock pairs that usually track together
- When the relationship is broken:
    - Buy the stock that is cheap compared to the usual relationship
    - Short sell the stock that is expensive compared to the usual relationship
- Hope the usual relationship is restored soon.

Model

- $P_1/P_2 \approx \text{constant}$
- When the ratio goes above the constant, it tends to come down.
- When the ratio goes below the constant, it tends to go up.

$$\Delta P_1/P_2 = \begin{cases} + \text{ when } P_1/P_2 < \text{constant} \\ - \text{ when } P_1/P_2 > \text{constant} \end{cases}$$

-Assume the change is larger when the ratio is further from the constant as

$$\Delta P_1/P_2 = k(\text{constant} - P_1/P_2)$$

for a constant $k > 0$.

- The model is equivalent to

$$\Delta P_1/P_2 = a + bP_1/P_2$$

where $a = k \times \text{constant}$, $b = -k$.

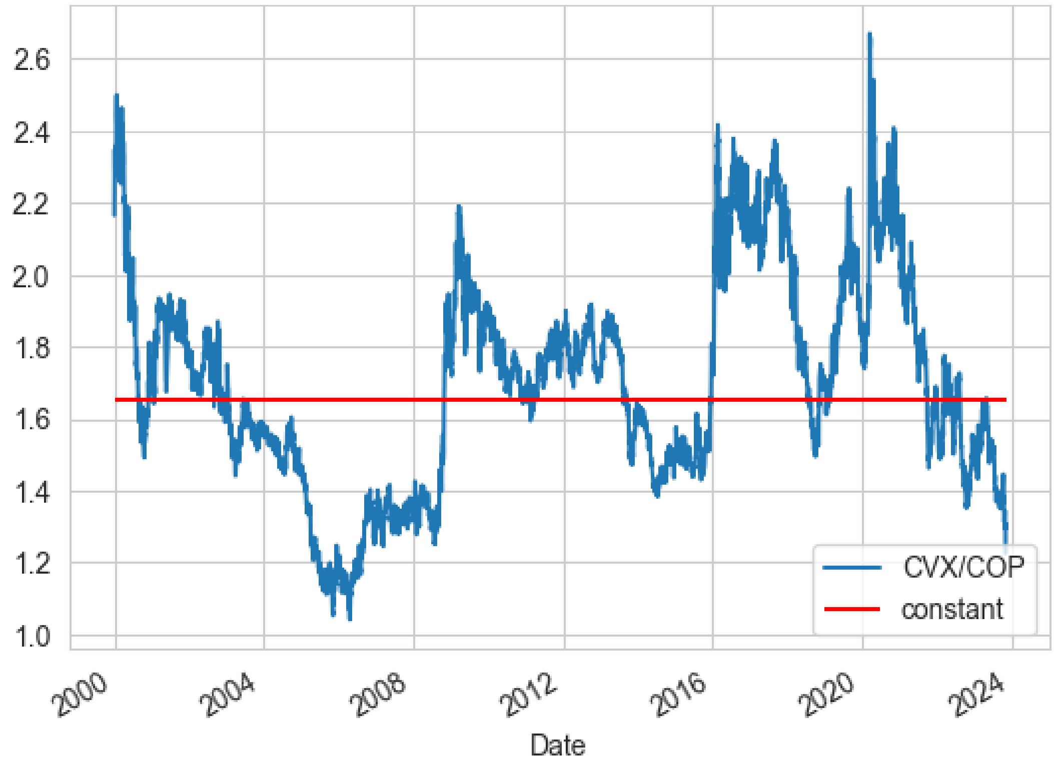
- Estimate a and b by linear regression.
- Should get $a > 0$, $b < 0$.
- If so, $\text{constant} = -a/b$.
- Hold asset 1 and short 2 when $P_1/P_2 < -a/b - \text{threshold}$.
- Hold asset 2 and short 1 when $P_1/P_2 > -a/b + \text{threshold}$.

Example

- Chevron (CVX) and Conoco-Phillips (COP) from 2000 on
- Adjusted closing prices from Yahoo Finance
- Compute the price ratio: CVX / COP

In [2]:

```
data.ratio.plot(label="CVX/COP")
plt.hlines(
    y=-a/b,
    xmin = data.index[0],
    xmax=data.index[-1],
    color="red",
    label="constant"
)
plt.legend(loc="lower right")
plt.show()
```



Returns

- $-a/b = 1.66$
- Set threshold = 0.2 as an example
- Buy COP and short CVX when CVX / COP is above 1.86
- Buy CVX and short COP when CVX / COP is below 1.46

Market Neutrality

- The pairs strategy is an example of a market neutral strategy, meaning its market beta should be approximately zero.
- If it has a return above the risk-free rate, then adding some of it to the market portfolio can improve performance relative to holding the market.
- This is the same as saying that the strategy has a positive alpha.
- It is also the same as saying

$$\text{Sharpe ratio of strategy} > \text{Sharpe ratio of market} \times \text{correlation with market}$$

- Get the market return from Ken French's data library.

In [4]:

```
print(f"mean return of pairs strategy = {252*data.ret.mean():.2%} annualized"
print(f"correlation of pairs strategy with market = {data.ret.corr(data.mkt):
```

```
mean return of pairs strategy = 5.19% annualized
correlation of pairs strategy with market = 4.94%
```

Avoid Look-Ahead Bias

- Compute the parameter of the strategy (the constant $-a/b$) from data through 2015
- Test the strategy from 2015 on.

In [7]:

```
print(f"mean return of pairs strategy = {252*future.ret.mean():.2%} annualize
print(f"correlation of pairs strategy with market = {future.ret.corr(future.m
```

```
mean return of pairs strategy = 5.48% annualized
correlation of pairs strategy with market = 10.74%
```

Alpha and Beta

- beta = corr with market excess return x std dev of strategy / std dev of market
- alpha = mean return - beta * mean market excess return

In [8]:

```python
beta = future.ret.corr(future.mkt) * future.ret.std() / future.mkt.std()
alpha = future.ret.mean() - beta * future.mkt.mean()

print(f"beta is {beta:.4f}")
print(f"annualized alpha is {252*alpha:.2%}")
```

```
beta is 0.0011
annualized alpha is 4.19%
```

Regressions in python

- use statsmodels.formula.api
- smf.ols("model", data).fit().summary()

In [9]:

```
import statsmodels.formula.api as smf
smf.ols("ret~mkt", future).fit().summary()
```

Out[9]:

OLS Regression Results

Dep. Variable:	ret	**R-squared:**	0.012
Model:	OLS	**Adj. R-squared:**	0.011
Method:	Least Squares	**F-statistic:**	25.15
Date:	Sat, 28 Oct 2023	**Prob (F-statistic):**	5.75e-07
Time:	11:42:18	**Log-Likelihood:**	6431.3
No. Observations:	2157	**AIC:**	-1.286e+04
Df Residuals:	2155	**BIC:**	-1.285e+04
Df Model:	1		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
Intercept	0.0002	0.000	0.758	0.448	-0.000	0.001
mkt	0.0011	0.000	5.015	0.000	0.001	0.002

Omnibus:	438.977	**Durbin-Watson:**	1.951
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	11512.640
Skew:	0.267	**Prob(JB):**	0.00
Kurtosis:	14.305	**Cond. No.**	1.20