Assignment 4 - You Wu

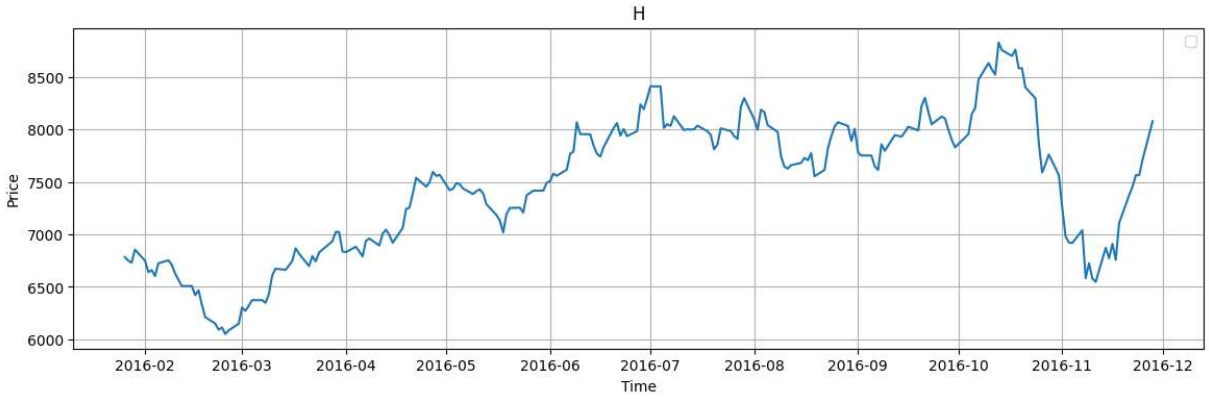
ERN, H, and XPR are **futures cash settlement contracts** based on energy reference prices. (Actually we don't know if XPR is also a cash settlement, but we assume it is.) ERN is calculated daily; H and XPR are calculated monthly.

1 unit of ERN is based on 1 unit of its settlement price; 1 unit of H is based on 2500 units of its settlement price; 1 unit XPR is based on 50 units of its settlement price (if its NYMEX Last Day Settlement Price is per MWH).

We don't have the data for futures prices, so we hedge against ERN with H and XPR based on their reference prices.

Assume we are holding N MW physical power of electricity. Assume N is big enough. Assume the markets of H and XPR are liquid enough.

Firstly, have a look at the daily prices of ERN, H, and XPR.



Calculate their correlation.

	ERN	H	XPR
ERN	1.000000	0.984395	-0.738712
H	0.984395	1.000000	-0.844944
XPR	-0.738712	-0.844944	1.000000

ERN, H, and XPR are all **highly correlated.**

Build OLS model.

OLS Regression Results

Dep. Variable:	ERN	R-squared:	0.999
Model:	OLS	Adj. R-squared:	0.999
Method:	Least Squares	F-statistic:	1.535e+05
Date:	Sun, 21 May 2023	Prob (F-statistic):	0.00
Time:	13:41:36	Log-Likelihood:	351.23
No. Observations:	219	AIC:	-696.5
Df Residuals:	216	BIC:	-686.3
Df Model:	2		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-25.2234	0.325	-77.620	0.000	-25.864	-24.583
H	0.0036	9.54e-06	373.320	0.000	0.004	0.004
XPR	0.0566	0.001	96.429	0.000	0.055	0.058

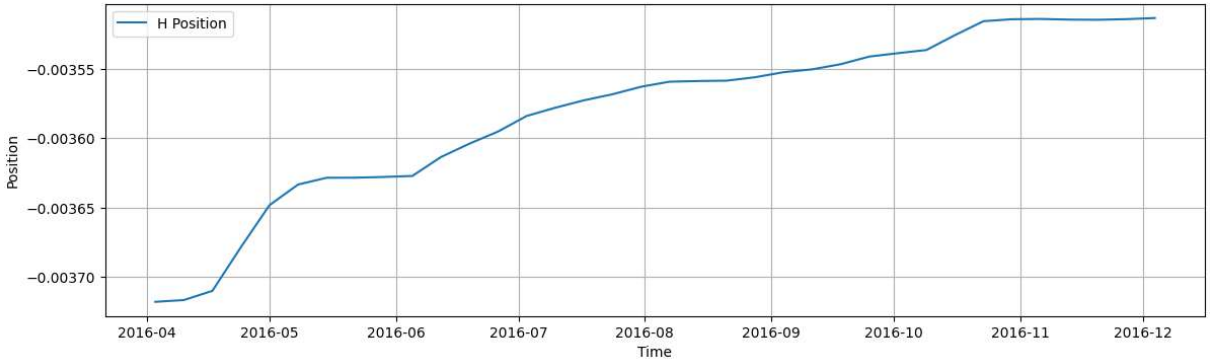
Omnibus:	48.191	Durbin-Watson:	0.092
Prob(Omnibus):	0.000	Jarque-Bera (JB):	73.189
Skew:	-1.289	Prob(JB):	1.28e-16
Kurtosis:	4.172	Cond. No.	7.36e+05

H and XPR are both very useful in predicting ERN, and due to R-squared, **they can explain 99.9% of the changes of ERN.**

Thus, consider using H and XPR to hedge ERN based on their OLS coefficients. We need some previous data to calculate how to hedge at each time point, so we start to hedge in April. (In April, we already have more than 40 daily data, which is enough for OLS).

In the requirement, we can rebalance H weekly, and can also use XPR for hedging without rebalancing. Thus, at the beginning of April when we start to hedge, we calculate the **OLS coefficient of XPR** (which is 0.053) and use it as our XPR position. Choose XPR contracts that expire at the end of the year as we can't rebalance it throughout the year. To be specific, we sell 0.053 * N units of XPR. Assuming N is big enough, 0.053 * N is approximately an integer.

Then we calculate the **OLS coefficient of H** every week based on past daily data and use it to rebalance our H position. Every week, choose H contracts that expire one week later as we'll rebalance it one week later.



For example, we sell 0.00365 * N units of H for the first week of May. Assuming N is big enough, 0.00365 * N is approximately an integer.

In this way, we construct a new portfolio that is much less volatile. The Excel shows our weekly positions. We use OLS coefficients as parameters to decide our rebalance. The std is much lower, so our hedging is quite efficient.

Time	ERN	H	XPR	H position	XPR position	Portfolio		ERN std (from April)	Constructed Portfolio std (from April)
2016/4/3	25.68	6930.00	463.27	-0.00372	0.0530				
2016/4/10	25.45	6881.50	462.33	-0.00372	0.0530	24.38			
2016/4/17	25.56	6972.50	458.17	-0.00371	0.0530	23.93			
2016/4/24	26.40	7298.00	452.26	-0.00368	0.0530	23.30			
2016/5/1	27.04	7535.50	448.55	-0.00365	0.0530	23.10			
2016/5/8	26.61	7452.50	446.32	-0.00363	0.0530	23.08			
2016/5/15	26.48	7381.50	448.45	-0.00363	0.0530	23.44		0.57	0.47
2016/5/22	25.81	7156.50	450.84	-0.00363	0.0530	23.75		0.55	0.44
2016/5/29	26.44	7329.50	450.91	-0.00363	0.0530	23.75		0.52	0.42
2016/6/5	27.14	7511.50	451.69	-0.00363	0.0530	23.84		0.57	0.40
2016/6/12	27.99	7841.00	446.18	-0.00361	0.0530	23.20		0.73	0.40
2016/6/19	27.85	7829.50	444.66	-0.00360	0.0530	23.13		0.80	0.40
2016/6/26	28.44	7992.50	444.73	-0.00360	0.0530	23.21		0.92	0.40
2016/7/3	29.18	8226.00	443.43	-0.00358	0.0530	23.12		1.09	0.39
2016/7/10	28.84	8128.50	443.54	-0.00358	0.0530	23.22		1.16	0.39
2016/7/17	28.29	8007.50	441.62	-0.00357	0.0530	23.05		1.16	0.39
2016/7/24	27.93	7923.50	440.65	-0.00357	0.0530	22.99		1.14	0.39
2016/7/31	28.41	8070.00	440.06	-0.00356	0.0530	22.94		1.14	0.39
2016/8/7	28.57	8099.00	441.01	-0.00356	0.0530	23.10		1.15	0.39

For example, on 2016/4/3, we have N units of ERN, and we sell 0.053 * N units of XPR and 0.00372 * N units of H. We will have a fixed cash income when we sell XPR and H based on their contract prices, and

make floating payments based on their reference prices. We hold these positions from 2016/4/3 to 2016/4/10. On 2016/4/10, our floating income from ERN and floating payments from H and XPR will be 24.38 in total. Then we rebalance our H position on 2016/4/10.

We only care about the floating values (floating incomes and payments). Ignore fixed cash incomes as we don't have data for contract prices. Focus on the **deviation from the mean** of the floating values.

When we only hold N units of ERN, the value is very volatile. When we hold our constructed portfolio, **the value is much less volatile**.

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ERN std:  1.368227044054324
Constructed Portfolio std:  0.3873625270170021
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Calculate the std of values from April to December. **The std of values decreases significantly**. We successfully hedged our exposure to ERN.