Verifying Whether the Common Used Leading Indicator Is Statistically Significant or Not

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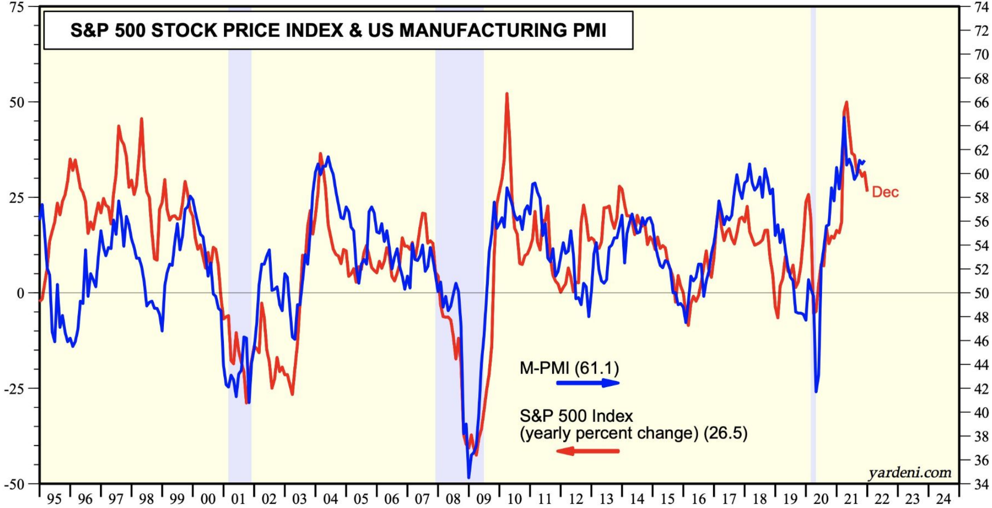
Outline

By using cross correlation analysis (CCF), we identified that PMI (Purchasing Managers' Index) is not a reliable metric for predicting SPX Index.

Furthermore, by performing Granger causality test, our results show that PMI do not granger cause SPX given any period.

Motivation



Note: Shaded areas are recessions according to the National Bureau of Economic Research.
Source: Standard & Poor's and Institute for Supply Management.

SPX and PMI Intro

- SPX, an abbreviation for the Standard & Poor's 500 Index, is widely regarded as one of the important indicators of the American stock market and is extensively used to assess the overall condition and trends of the stock market.

- It serves as a crucial tool for many investors, analysts, and institutions to evaluate market risks and returns.

SPX and PMI Intro

- PMI (Purchasing Managers' Index), an economic indicator that measures the level of manufacturing or non-manufacturing activities.

- PMI ranges from 0 to 100. Generally, if the PMI value is above 50, it indicates that economic activity has grown relative to the previous month, signifying an expansionary phase of the economy. While PMI 50 indicates indicates a contractionary phase of the economy.

Why PMI？ Relation to SPX？

Components of PMI :

1. Production (生產)
2. New Orders (新訂單)
3. Employment (人力雇用)
4. Supplier Deliveries (供應商交貨時間)
5. Inventories (存貨)
6. Customers' Inventories (客戶存貨)
7. Prices (原料價格)
8. Blaacklog of Orders (未交貨訂單)
9. New Export Orders (新出口訂單)
10. Imports (進口)

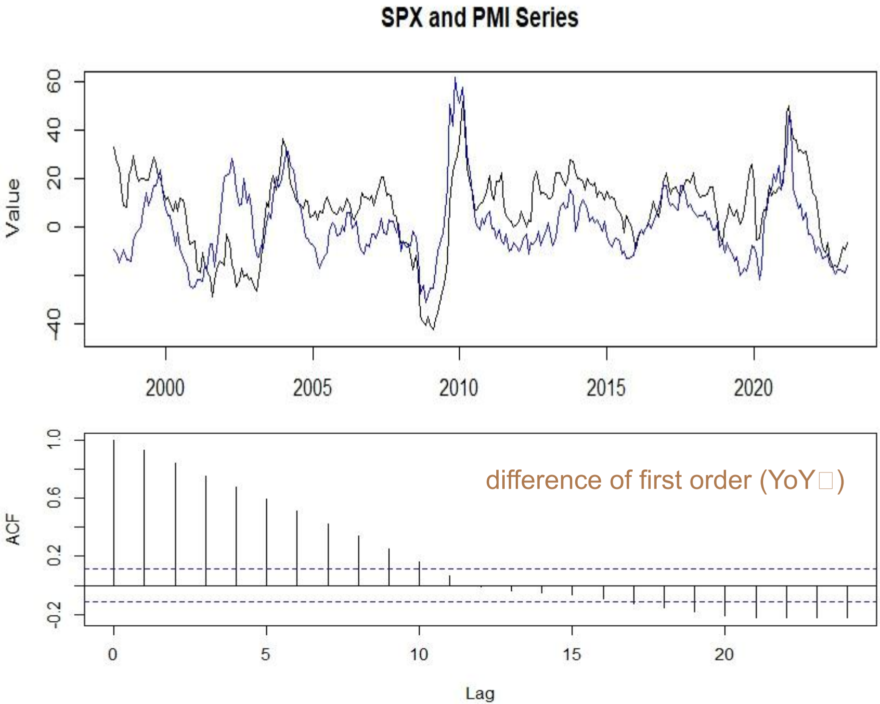
Data we use

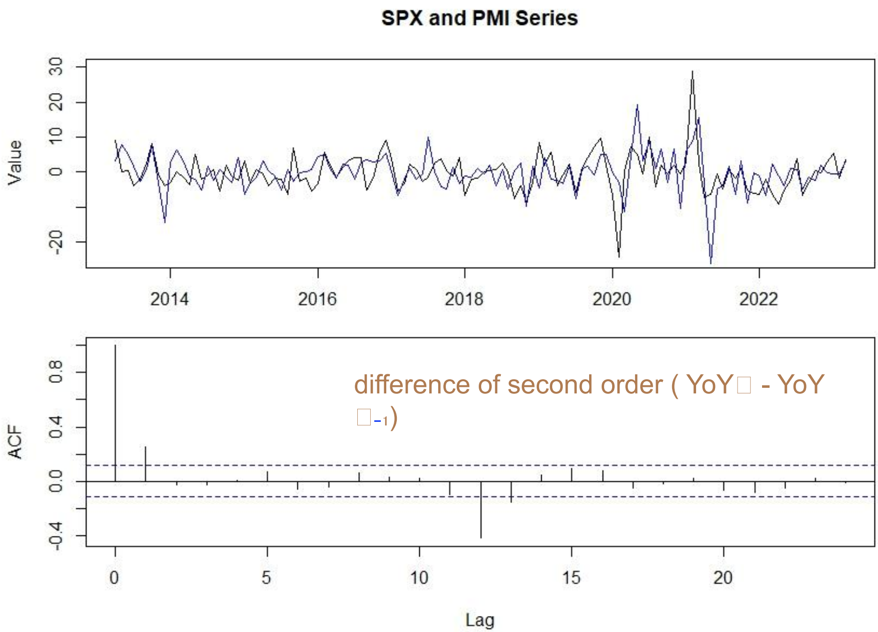
- Bloomberg
  SPX Annual Price change (dYoY)
  PMI Annual change (dYoY)

- Time interval: 1983~2023

Review of assumptions

- **Linearity** : The relationship between X and the mean of Y is linear.
- **Independence (No autocorrelation)**: Observations / residuals are independent of each other.
- **No or little multicollinearity :** X^TX is non-singular
- **Homoscedasticity** : The variance of residual is the same for any value of X.

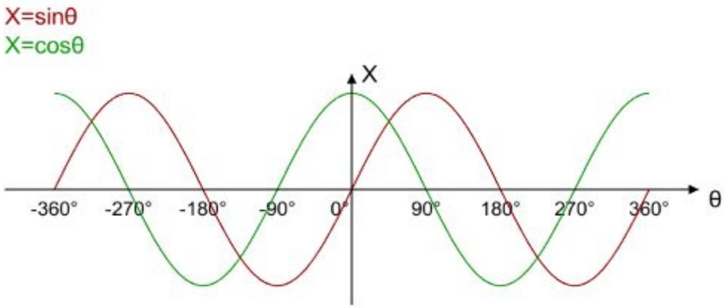

SPX and PMI Series
Value
60
40
20
0
-40
2000
2005
2010
2015
2020
ACF
1.0
0.6
0.2
-0.2
0
5
10
15
20
Lag
difference of first order (YoY□)



difference of second order (YoY□ - YoY □-1)

Cross-Correlation analysis

- Measures the similarity or relationship between two time series or signals
- It involves computing the correlation coefficient between corresponding values of the two series at different time lags



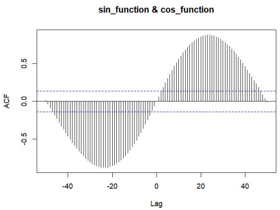
Cross-Corelation Analysis in R : ccf()

- `x <- seq(-2*pi, 2*pi, length.out = 200)`
- `sin_function  <- sin(x)`
  `cos_function  <- cos(x)`

```
C <- ccf( sin_function , cos_function , lag.max = 25)
```

```
Autocorrelations of series 'X', by lag

   -25    -24    -23    -22    -21    -20    -19    -18    -17    -16    -15    -14    -13    -12    -11    -10     -9 
-0.876 -0.879 -0.880 -0.876 -0.869 -0.858 -0.844 -0.826 -0.805 -0.780 -0.751 -0.719 -0.684 -0.646 -0.605 -0.561 -0.514 
    -8     -7     -6     -5     -4     -3     -2     -1      0      1      2      3      4      5      6      7      8 
-0.465 -0.413 -0.359 -0.303 -0.245 -0.186 -0.125 -0.063  0.000  0.063  0.125  0.186  0.245  0.303  0.359  0.413  0.465 
     9     10     11     12     13     14     15     16     17     18     19     20     21     22     23     24     25 
 0.514  0.561  0.605  0.646  0.684  0.719  0.751  0.780  0.805  0.826  0.844  0.858  0.869  0.876  0.880  0.879  0.876 
```



Granger's causality

- Examine if one time series may be used to forecast another.
- We say X does not granger cause Y , if and only if predictions of Y based on the universe of predictors U is not better than the predictions based on U - {X}

$$Y_t = \alpha_0 + \sum_{i=1}^{j} \alpha_i Y_{t-i}$$

$$Y_t = \lambda_0 + \sum_{i=1}^{j} \lambda_i Y_{t-i} + \sum_{i=0}^{j} \beta_i X_{t-i} + \epsilon_t$$

$$H_0 : \beta_1 = \beta_2 = \ldots = \beta_j = 0$$

Granger test In R

- grangertest(X , Y , order = j)
- order : integer specifying the order of lags to include in the auxiliary regression.

```
$`1998 ~ 2003`[[2]]
Granger causality test

Model 1: Y ~ Lags(Y, 1:7) + Lags(X, 1:7)
Model 2: Y ~ Lags(Y, 1:7)
  Res.Df Df     F Pr(>F)
1     38
2     45 -7 2.86  0.017 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Review of assumptions

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Modeling

$$\begin{bmatrix} Y_t \\ Y_{t-1} \\ \vdots \\ Y_{t-k} \end{bmatrix} = \begin{bmatrix} 1 & Y_{t-1} & \dots & Y_{t-j} & X_t & \dots & X_{t-j} \\ 1 & Y_{t-1} & \dots & Y_{t-1-j} & X_{t-1} & \dots & X_{t-1-j} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 1 & Y_{t-k} & \dots & Y_{t-k-j} & X_{t-k} & \dots & X_{t-k-j} \end{bmatrix} \begin{bmatrix} \lambda_0 \\ \lambda_1 \\ \vdots \\ \lambda_j \\ \beta_0 \\ \vdots \\ \beta_j \end{bmatrix} + \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ \vdots \\ \epsilon_k \end{bmatrix}$$

- Where k = sample size and j = lag month

Partial correlation

- Measures the association between two variables while controlling for the effects of other variables
- We have :

$$r_{xy.Z} = \frac{r_{xy} - \sum_{i=1}^{n} r_{xi} \cdot r_{yi|Z_i}}{\sqrt{(1 - r_{x_1}^2)(1 - r_{y_1|Z_1}^2) \cdot (1 - r_{x_2}^2)(1 - r_{y_2|Z_2}^2) \cdot \ldots \cdot (1 - r_{x_n}^2)(1 - r_{y_n|Z_n}^2)}}$$

$$x = \mathrm{SPX}_t \quad y = \mathrm{PMI}_j \quad z = \mathrm{SPX}_{-t} \cup \mathrm{PMI}_{-j}$$

Test Procedure

1. Cross-Correlation analysis

   ccf (PMIseries , SPXseries)

   >> lag month & correlation coefficient

2. Granger's causality test

   grangertest (SPXseries ~ PMIseries , order = lag month)

   >> F statistics & P_value

3. Partial correlation

   pcor (cor (data.frame (SPX□ , SPX□-□ , PMI□ , PMI□-□)))

   >> partial correlation coefficient of PMI & SPX

Testing Results

	Lag(corr)	$\Pr(>F)$	**pcor**
2018-2023	-1(0.47)	NA	NA
2013-2018	1(0.29)	0.61	NA
2008-2013	0(0.56)	0.24	NA
2003-2008	-1(0.47)	NA	NA
1998-2003	-1(0.41)	NA	NA
1993-1998	0(0.26)	0.88	NA
1988-1993	-4(0.26)	NA	NA
1983-1988	-5(0.37)	NA	NA

Summary

1. Some people tend to use PMI as an investment decision. However, according to our research methods, PMI will lead SPX only from 2013 to 2018, and the remaining 35 years will be at the same time or behind.

2. The Grangertest results suggest that the PMI is not helpful in predicting SPX movements.

3. We also looked at other indicators, such as BEst (eps forcast) and CEO index (CEO Confidence Questionnaire), and the results were similar.

Something You May Ask …

1. CCF has a loss term, are the results reliable?
2. Why choose to use 5 years to anaylize?
3. R executes grangertest. If order = 0, the result cannot be obtained? Why is df < 0?
4. Why does the order of Grangertest not refer to AIC criteria?
5. How to deal with autocorrelation of residual terms?

Can be improved: Use Ridge regression or PCA to handle collinearity

References

1. https://baike.baidu.com/item/%E6%A0%BC%E5%85%B0%E6%9D%B0%E5%9B%A0%E6%9E%9C%E5%85%B3%E7%B3%BB%E6%A3%80%E9%AA%8C/2485970 (Definition of Granger Causality)

2. https://research.stlouisfed.org/wp/more/1984-001 (Practical application of Granger causality test)

Other Testing results

- SPX ~ BEst
- SPX ~ CEO

GIthub : https://github.com/blossmuri/EconProject.git

Contact: b09508009@ntu.edu.tw

That's All

THANK
YOU