

# Factor Strength and Factor Selection

## An Application to U.S. Stock Market

### Research Plan Presentation

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## explanation

Capital Asset Pricing Model (CAPM) is the benchmark of risk pricing.

$$r_{it} - r_{ft} = a_i + \beta_{im}(r_{mt} - r_{ft}) + \sum_{j=1}^k \beta_{ij}f_{jt} + \varepsilon_{it}$$

- $r_{it}$ : asset's return
- $r_{ft}$ : risk free return
- $a_i$ : constant/intercept
- $\beta_{im}$ : market factor loading
- $r_{mt}$ : market return
- $\beta_{ij}$ : risk factor loading
- $f_{jt}$ : risk factor
- $\varepsilon_{it}$ : stochastic error
- **Add factors to enhance risk pricing.**
- **New factors are booming**

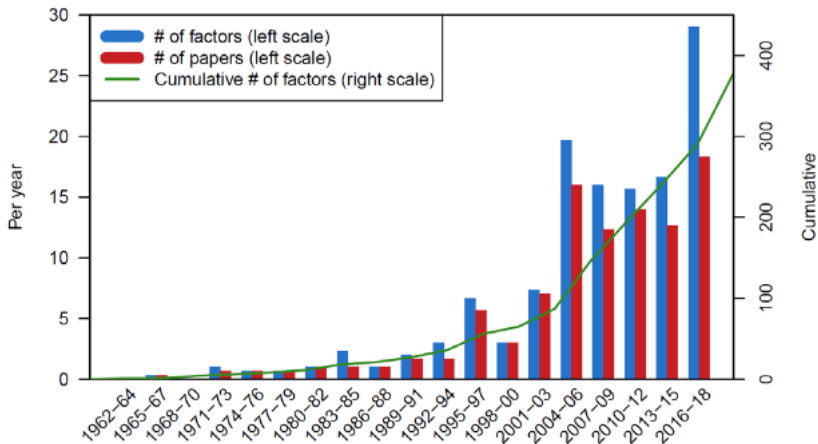


Figure: Factor amount growing through the year.

(Harvey & Liu, 2019)

# Factor Strength

The research interest is pricing risk, so factor strength matter.  
Consistency of risk pricing is dependent on the strength of factor (Pesaran & Smith, 2019)

Factor strength is defined in terms of factor loading (Bailey, Kapetanios, & Pesaran, 2020) as follow.

Strong factor  $\Rightarrow$  price more asset's risk  $\Rightarrow$  generate more significantly loadings.

Assume we have  $N$  different assets.

$$|\beta_j| > CV, j = 1, 2, 3, \dots, [N^{\alpha_j}]$$

$$|\beta_j| = 0, j = [N^{\alpha_j}] + 1, [N^{\alpha_j}] + 2, [N^{\alpha_j}] + 3, \dots, N$$

# Introduction and Motivation

But some problems exist among all those factors.

- Including Factor without correlation with return in FM first-regression(Fama & MacBeth, 1973) will yield misleading second regression result (Kan & Zhang, 1999)
- If the factor loading is small, estimated risk premia will be spurious Kleibergen (2009)

Reference to this problem is made in the literature:

Kan and Zhang (1999), Kleibergen (2009), Kleibergen and Zhan (2015), Gospodinov, Kan, and Robotti (2017), Anatolyev and Mikusheva (2018)

# Literature

- **Identify factors**

Harvey, Liu, and Zhu (2015), McLean and Pontiff (2016), Harvey and Liu (2017), Barillas and Shanken (2018), Pukthuanthong, Roll, and Subrahmanyam (2019)

- **Using machine learning method**

Rapach, Strauss, and Zhou (2013), Feng, Giglio, and Xiu (2019), Gu, Kelly, and Xiu (2020), Lettau and Pelger (2020), Freyberger, Neuhierl, and Weber (2020), Kozak, Nagel, and Santosh (2020)

# Main Problem

This project faces two challenges:

1. High dimensions of data group

How to identify the significant one.  $\Rightarrow$  use factor strength as criteria.

2. Correlation among factors

Traditional variable selection algorithm (Lasso) can not handle this.  $\Rightarrow$  Will use elastic net techniques

# Elastic Net

Introduced by Zou and Hastie (2005), is an improved method to select factors.

Considering the following loss function:

$$\hat{\beta}_{ij} = \arg \min_{\beta_{ij}} \left\{ \sum_{i=1}^n [(r_{it} - r_{ft}) - \beta_{ij} f_{jt}]^2 + \lambda_2 \sum_{i=1}^n \beta_{ij}^2 + \lambda_1 \sum_{i=1}^n |\beta_{ij}| \right\}$$

The  $L_1$  norm  $\sum_{i=1}^n |\beta_{ij}|$  helps select the factors, reduce redundancy.

The  $L_2$  norm  $\sum_{i=1}^n \beta_{ij}^2$  helps handle the correlation.



# Preliminary Result

Use Monte Carlo simulation to study the property of estimated factor strength.

$$\hat{\alpha} = \begin{cases} 1 + \frac{\ln(\hat{\pi}_{nT})}{\ln n} & \text{if } \hat{\pi}_{nT} > 0, \\ 0, & \text{if } \hat{\pi}_{nT} = 0. \end{cases}$$

- Overestimates occurs when strength is low  
 $\alpha = 0.5, \hat{\alpha} \approx 0.7$
- But the precision improved with strength increase  
 $\alpha = 0.7, \hat{\alpha} = 0.8$
- When we have the strong factor, we have the unbiased estimator  $\alpha = \hat{\alpha} = 1$

# Future Plan

For the next step, we will start the empirical analyses.  
We will collect and exam the data for the empirical research.

- **Assets:** Companies from Standard & Poor (S&P) 500 index
- **Time period:** 2008-2018, 10 years, monthly return.
- **Factor:** Factors from Harvey and Liu (2019)'s factor list

Using factor strength as the criterion to trim first, and then applied the elastic net method.

# Thanks for listening

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