Long/Short Global Macro Strategies with Target Beta Using the 3-Factor Model

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ABSTRACT

In this project we construct a Long/Short Global Macro Strategy based on French Fama 3-Factor Model with a target beta term and evaluate its sensitivity to variation of Beta and its sensitivity to the length of the estimation for covariance matrix and the expected returns under different market scenarios. Several comparisons are drawn between each beta term and term structure combinations.

KEYWORDS - Global Macroeconomic Trends, Long/Short, French, Fama, Beta, 3-Factor Model, Trading Strategies, Portfolio Management

I. INTRODUCTION

FAMA FRENCH 3-FACTOR MODEL

Historically, French Fama 3-Factor Model is regarded as a development of CAPM which explains a relationship between expected returns and risk factors.
Fama and French proposed the eponymous French Fama 3-factor model which describes a cross section of average stock returns using three factors: market risk premium, market equity, and book-to-market ratio.

Under the 3-factor model, the random return of security is given by the formula,

$$r_i - r_f = \alpha_i + \beta_i^{MKT}(r_m - r_f) + \beta_i^{SMB} r_i^{SMB} + \beta_i^{HML} r_i^{HML} + \epsilon_i \quad (1)$$

With $E[\epsilon_i] = 0$, $E[r_i] = R_i$, $E[r_m] = R_m$, $E[r_i^{SMB}] = R_{SMB}$, $E[r_i^{HML}] = R_{HML}$, the expected return on a given security can be written as

$$R_i - r_f = \alpha_i + \beta_i^{MKT}(R_M - r_f) + \beta_i^{SMB} R_{SMB} + \beta_i^{HML} R_{HML} \quad (2)$$

Where r_i is a random return on a security, r_f is a risk-free rate, r_M is a market return, and three βs, β_i^{MKT}, β_i^{SMB}, β_i^{HML} is a sensitivity measure for risk premium of market portfolio, risk factor of market equity, and risk factor of book-to-market ratio, respectively.

MARKOWITZ PORTFOLIO

Markowitz portfolio theory also known as modern portfolio theory is a theory on how risk-averse investors can construct portfolio to maximize expected return based on a given level of market risk. The theory can also be used to construct a portfolio that minimize risk for a given level of expected return. In mathematical format:

$$\min_{\omega} \omega^T \Sigma \omega \quad (3)$$

$$e^T \omega = 1 \quad (4)$$

$$\rho^T \omega = \rho_T$$

Where ω is a vector of weights of securities, Σ is a covariance matrix , ρ is an expected return, ρ_T is a target return.

LINEAR REGRESSION

An approach for predicting a quantitative response Y n the basis of multiple predictor variable X_j that assume an approximately linear relationship between X_j and Y. For a model with p predictors, the linear regression takes the form

$$Y = \beta_0 + \sum_{j=1}^{p} \beta_j X_j + \varepsilon \quad (5)$$

where X_j is the j th predictor and β_j qualifies the relationship between that predictor and the response. Given estimates for $\beta' s$, it can make predictors using the model

$$\hat{f}(X) = \hat{\beta}_0 + \sum_{j=1}^{p} \hat{\beta}_j X_j \quad (6)$$

where we estimate these parameters by minimizing the residual sum of squares

$$RSS = \sum_{i=1}^{n} (y_i - \hat{\beta}_0 - \sum_{j=1}^{p} \hat{\beta}_j X_j)^2 \quad (7)$$

II. INVESTMENT UNIVERSE & BACKTESTING

DATA

We used the 12 ETFs belowfrom March 1, 2007 to June 30, 2020:

1. CurrencyShares Euro Trust (FXE)
2. iShares MSCI Japan Index (EWJ)
3. SPDR GOLD Trust (GLD)
4. PowerShares NASDAQ-100 Trust (QQQ)
5. SPDR S&P 500 (SPY)
6. iShares Lehman Short Treasury Bond (SHV)
7. PowerShares DB Agriculture Fund (DBA)
8. United States Oil Fund LP (USO)
9. SPDR S&P Biontech (XBI)
10. iShares S&P Latin America 40 Index (ILF)
11. iShares MSCI Pacific ex-Japan Index Fund (EPP)
12. SPDR DJ Euro Stoxx 50 (FEZ)

The S&P 500 (SPY) was chosen to be the analysis benchmark. Lastly, the data used to construct the French Fama 3-Factor Model is quoted from Ken French's website for the factors' historical values.

INVESTMENT HORIZON

The investment horizon was divided into the following sub-periods:

1. Pre-Subprime Crisis : March 22, 2007 – March 3, 2008
2. During Subprime Crisis : March 3, 2008 – September 10, 2010
3. Post-Subprime Crisis : September 10, 2010 – January1, 2015
4. Pre-COVID-19 Pandemic : January 1, 2015 – March 9, 2020
5. During COVID-19 Pandemic : March 9, 2020 – October 30, 2020

BACKTESTING

Individual backtests were executed for each sub-period to compare strategies. We compared with different perspectives.

We considered the impact of each term structure and estimation term combination with a range of target β values, across each sub-period of the investment horizon. S_j^i represents a term structure with i days lookback period to estimate the expected return and j days lookback period to estimate the covariance matrix.

We also ran a backtest across the full investment horizon, from March 1st, 2007 to November 30th, 2020.

INVESTMENT STRATEGY

We considered the following investment strategy,

$$\max_{\omega} \rho^T \omega - \lambda(\omega - \omega_p)^T \Sigma(\omega - \omega_p) \quad (8)$$

constrained by,

$$\sum_{i=1}^{n} \beta_i^m \omega_i = \beta_T^m \quad (9)$$

$$\sum_{i=1}^{n} \omega_i = 1$$

where,

- ω_i : weight allocated to each security S_i,
- ω is the vector of weights for all securities S_i in the Portfolio,
- ρ : a vector of expected returns of security S_i,
- Σ : the covariance matrix between securities returns derived from the Factor model,
- ω_p : composition of a reference Portfolio, the previous portfolio when rebalancing the portfolio,
- λ : small regularization parameter to limit turnover,
- $\beta_i^m = \frac{cov(r_i, r_M)}{\sigma^2(r_M)}$: the beta term of each security S_i
- β_T^m : the Portfolio's target beta term.

ESTIMATION TERMS AND TARGET BETA

We analyzed the following combinations of term structures and beta terms for the following strategies: S_{60}^{60}, S_{120}^{60}, S_{60}^{90}, S_{120}^{90}, S_{60}^{120}, S_{120}^{120}. The following target betas were tested for each investment strategy: $\beta_T^m = \{-1.0, -0.5, 0.5, 1.0, 1.5, 2.0\}$

PERFORMANCE AND RISK METRICS

The following performance and risk metrics were selected. To evaluate performance we computed the Cumulated Return, Annual Arithmetic Mean/Geometric Mean Return, Annual Min Return, Max 10-days Drawdown and Sharpe Ratio of the investment strategies. To assess the risk of each strategy, we considered Volatility, Daily VaR, Annual VaR, Modified VaR, Annual CVaR, Skewness and Kurtosis. In estimating the annualized metrics, we assume that each year includes 250 trading days

III. RESULTS & DISCUSSION

The daily Profit and Loss (P&L) graph of an investment of $100 was chosen to get a visual overview of strategy performance.

BEFORE THE SUBPRIME CRISIS

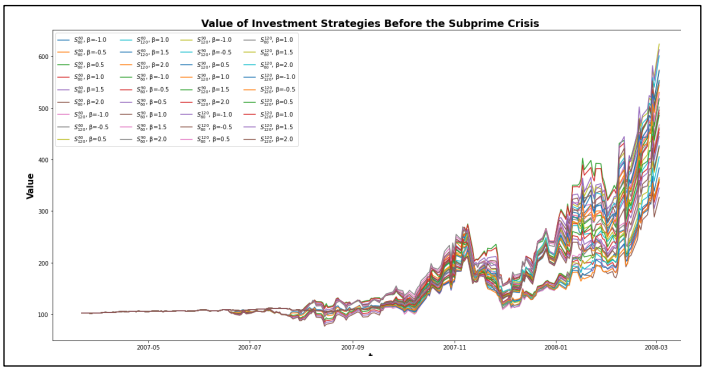

Fig. 1: Evolution of cumulated daily profit and loss for several portfolio strategies (Pre-Subprime Crisis)

The distributions of daily return for each investment strategy in the sub-period are shown in Fig. 2,

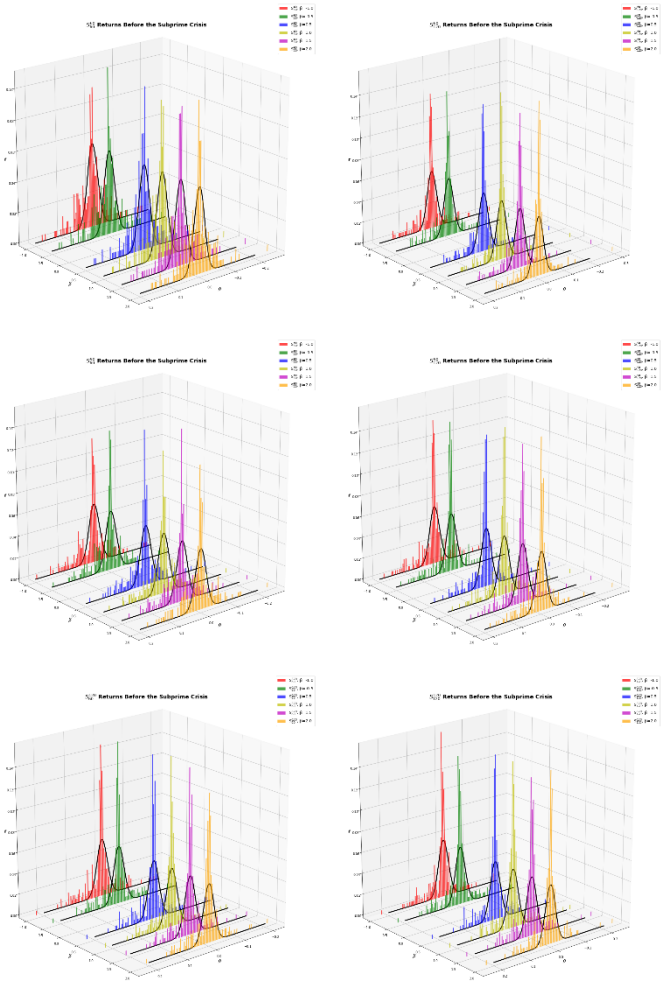

Fig. 2: left to right, top to bottom: distribution of daily returns of S_{60}^{60}, S_{60}^{120}, S_{90}^{60}, S_{90}^{120}, S_{120}^{60} and S_{120}^{120}.

DURING THE SUBPRIME CRISIS

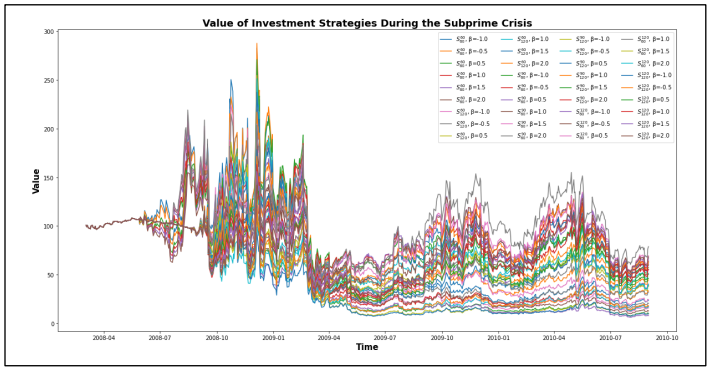

Fig. 3: Evolution of cumulated daily profit and loss for several portfolio strategies (During the Subprime Crisis)

The distributions of daily return for each investment strategy in the sub-period are shown in Fig. 4,

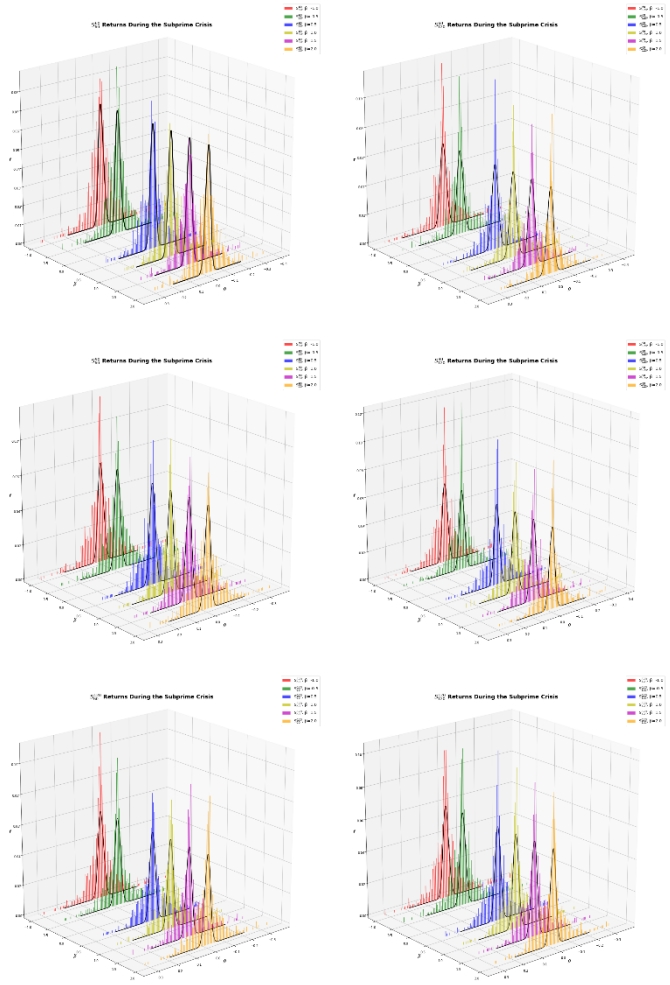

Fig. 4: left to right, top to bottom: distribution of daily returns of S_{60}^{60}, S_{60}^{120}, S_{90}^{60}, S_{90}^{120}, S_{120}^{60} and S_{120}^{120}.

AFTER THE SUBPRIME CRISIS

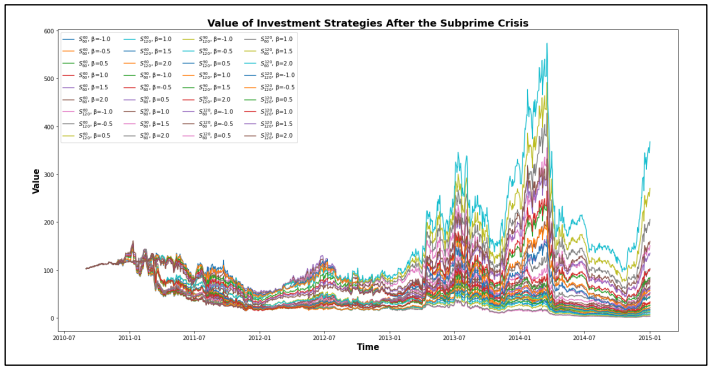

Fig. 5: the evolution of cumulated daily profit and loss for several portfolio strategies (During Subprime Crisis)

The distributions of daily return for each investment strategy in the sub-period are shown in Fig. 6,

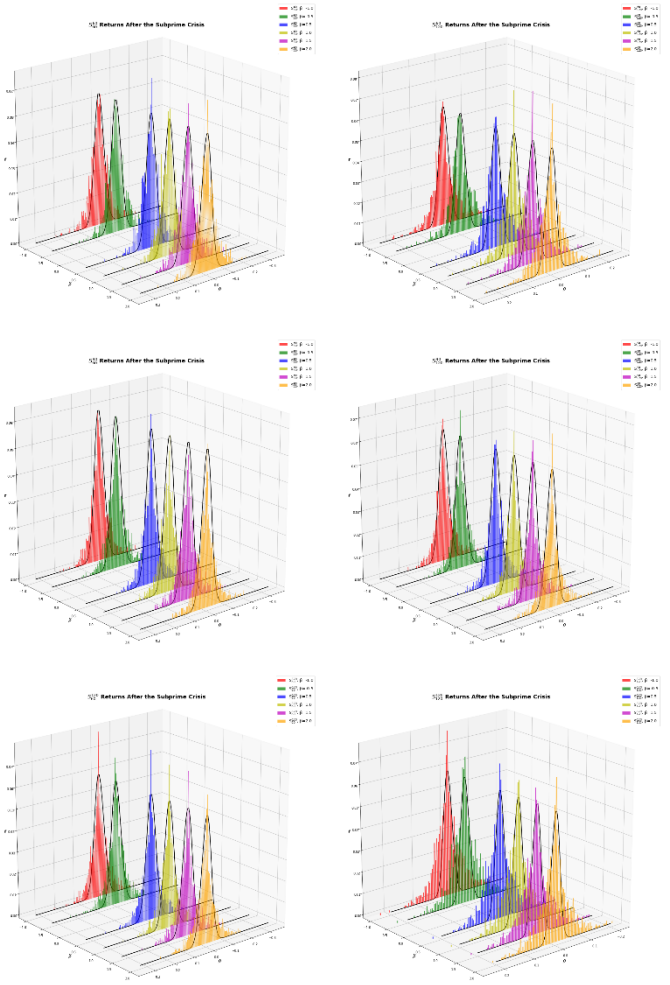

Fig. 6: left to right, top to bottom: distribution of daily returns of S_{60}^{60}, S_{60}^{120}, S_{90}^{60}, S_{90}^{120}, S_{120}^{60} and S_{120}^{120}.

BEFORE COVID-19

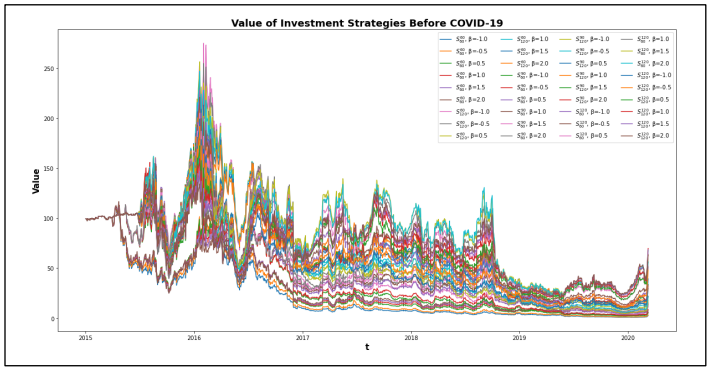

Fig. 7: left to right, top to bottom: distribution of daily returns of S_{60}^{60}, S_{60}^{120}, S_{90}^{60}, S_{90}^{120}, S_{120}^{60} and S_{120}^{120} across the sub-period March 3, 2008 – September 10, 2010.

The distributions of daily return for each investment strategy in the sub-period are shown in Fig. 8,

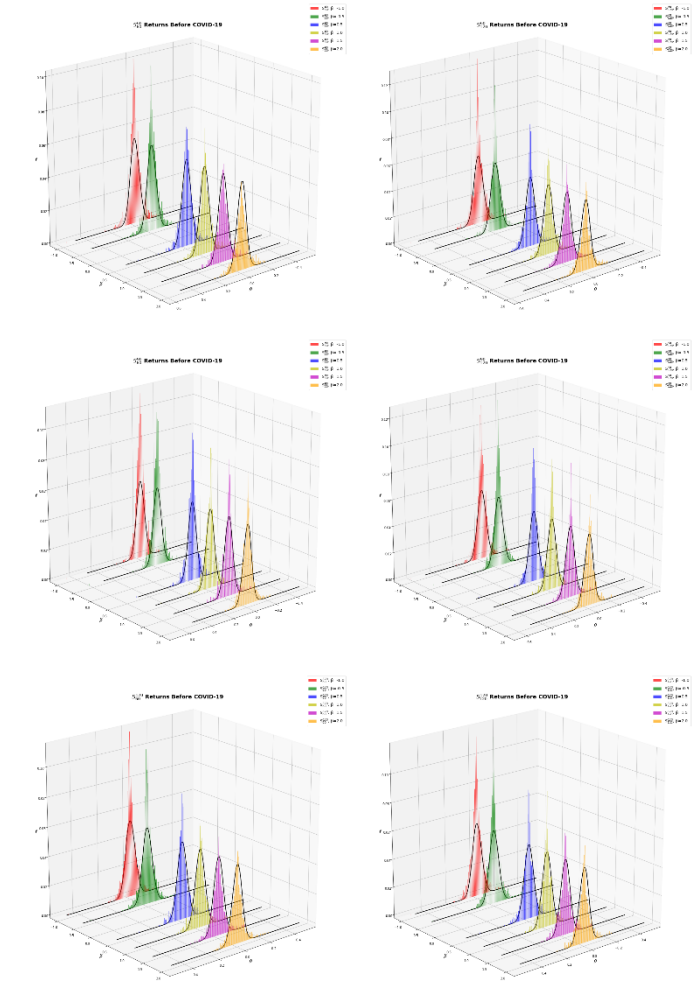

Fig. 8: left to right, top to bottom: distribution of daily returns of S_{60}^{60}, S_{60}^{120}, S_{90}^{60}, S_{90}^{120}, S_{120}^{60} and S_{120}^{120}.

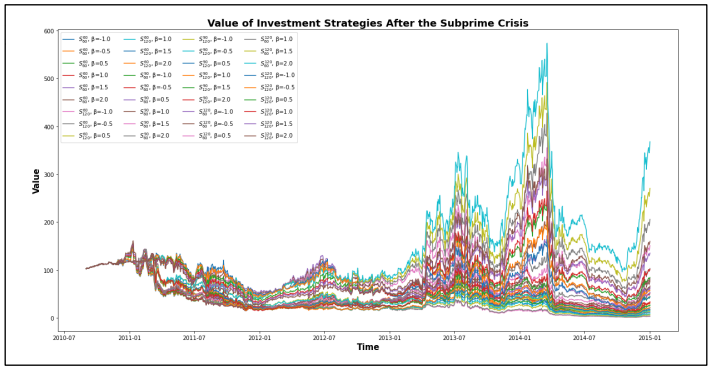

Fig. 9: the evolution of cumulated daily profit and loss for several portfolio strategies (During Subprime Crisis)

The distributions of daily return for each investment strategy in the sub-period are shown in Fig. 10,

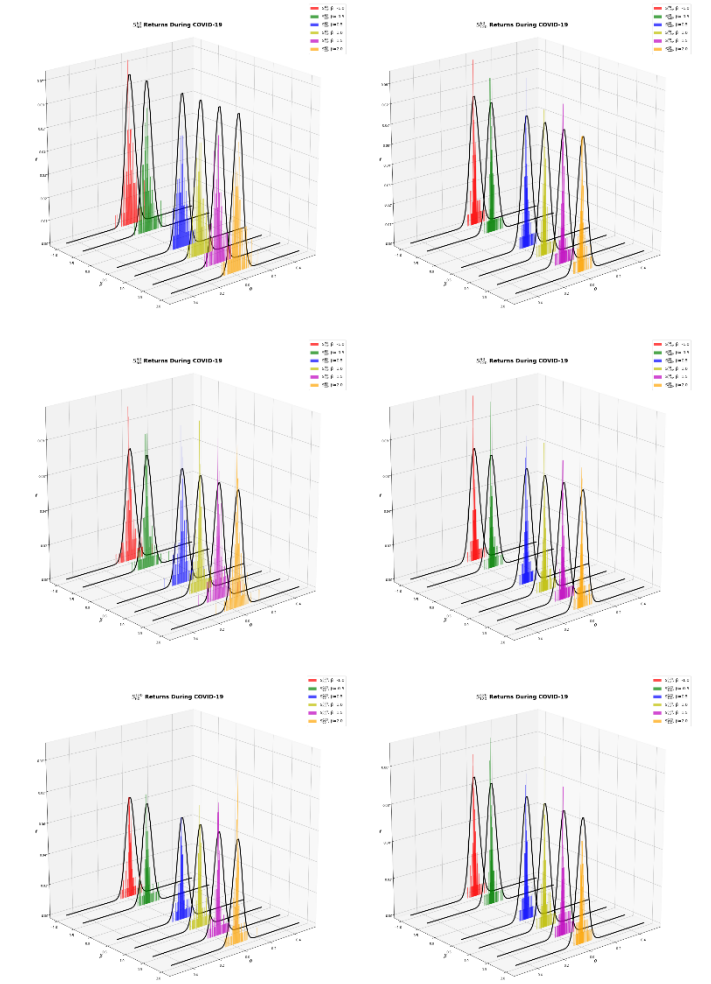

Fig. 10: left to right, top to bottom: distribution of daily returns of S_{60}^{60}, S_{60}^{120}, S_{90}^{60}, S_{90}^{120}, S_{120}^{60} and S_{120}^{120}.

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