Replication of the Fama French 3 Factor Model and Relevance Today

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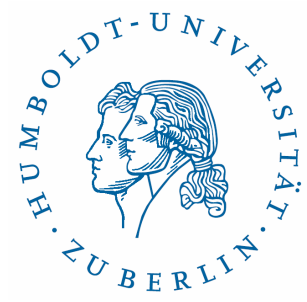
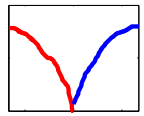


Structure I

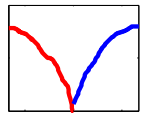


Structure II

Applying the Fama-French Model to the S&P 500

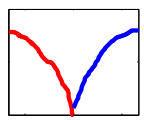
- Data Preparation
- Fama-French in 2010-2017
- Trend Analysis in 1980-2015
- Varying Sample Sizes
- Correlation of The factors and Top 20 and Bottom 20 returns

Conclusion



Purpose of the Study

- replicate the Fama-French Three-Factor model (1993)
- apply it to recent data (2010-2017)
- assess the explanatory power for the Fama-French Three-Factor model over different periods



Theory and Design

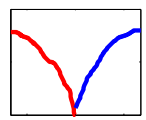
The Capital Asset Pricing Model:

$$R_i - R_F = \beta_M \cdot (R_M - R_F)$$

The Fama-French asset pricing Model:

$$R_i - R_F = \beta_M \cdot (R_M - R_F) + \beta_S \cdot SMB + \beta_V \cdot HML$$

- $R_I - R_F$ is an excess return of the stock or portfolio
- β_M is the sensitivity coefficient
- SMB is a small minus big (in terms of capitalization)
- HML is high minus low (in terms of book-to-value ratio)

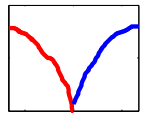


Data Preparation for Model Replication

Data:

- Fama/French 3 Factors (monthly)
- 25 Portfolios Formed on Size and Book-to-Market (5x5) (Value-Weighted)

source: Fama French Homepage



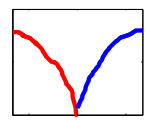
Fama/French 3 Factors

	Mkt-RF	SMB	HML	RF
192607	2.96	-2.30	-2.87	0.22
192608	2.64	-1.40	4.19	0.25
...				
199112	10.84	-2.22	-4.01	0.38

- CRSP firms listed on the NYSE, AMEX, and NASDAQ

$$SMB = \frac{1}{3}(SmallValue + SmallNeutral + SmallGrowth) - \frac{1}{3}(BigValue + BigNeutral + BigGrowth)$$

$$HML = \frac{1}{2}(SmallValue + BigValue) - \frac{1}{2}(SmallGrowth + BigGrowth)$$

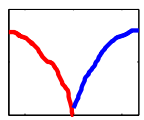


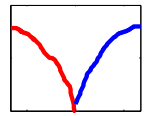
25 Value-Weighted Portfolios

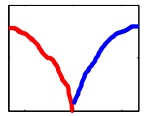
	Low	2	3	4	High
Small	SMALL LoBM	ME1 BM2	ME1 BM3	ME1 BM4	SMALL HiBM
2	ME2 BM1	ME2 BM2	ME2 BM3	ME2 BM4	ME2 BM5
3	ME3 BM1	ME3 BM2	ME3 BM3	ME3 BM4	ME3 BM5
4	ME4 BM1	ME4 BM2	ME4 BM3	ME4 BM4	ME4 BM5
Big	BIG LoBM	ME5 BM2	ME5 BM3	ME5 BM4	BIG HiBM

Table 1: Structure of the 25 Value-Weighted Portfolios

- High BM (Book to Market) stocks are value stocks
- Big ME (Market Equity) stocks are large companies by market capitalization
- Each value is that portfolio's monthly percentage return
-



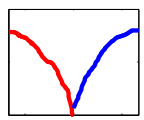




Batch Regression

- Use multivariate regression

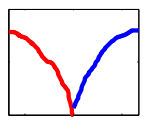
```
# batch regressing 25 portfolios
results <- list()
# Data starts from the 2nd col of P25
for (i in 1:(ncol(P25) - 1)) {
  rirf <- unlist (P25[, i + 1]) - rf
     y <- lm (rirf ~ rmrf + smb + hml)
  results[[i]] <- summary (y)
}
```

Formatting the Results

- Save all coefficients of regression results as vectors

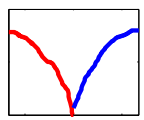
```
1 for(i in 1:(ncol(P25)-1)) {
2   betas <- cbind(betas,results[[i]]$coefficients
      [,1])
3   std.errors <- cbind(std.errors,results[[i]]$sigma)
4   t.values <- cbind(t.values, results[[i]]
      $coefficients[,3])
5   R.squareds <- cbind(R.squareds, results[[i]]$adj.r
      .squared)
6 }
```

Replicating Table 6 (1993)

- Resize the output to 5x5 format as in the Fama-French paper

```
resize <- function(x) {
  df = data.frame (matrix(x, nrow=5, byrow = TRUE))
  colnames(df) = c("Low", "2", "3", "4", "High")
  rownames(df) = c("Small", "2", "3", "4", "Big")
  return(df)
}
```

b	LOW	2	3	4	HIGH
SMALL	1.03	0.97	0.94	0.89	0.95
2	1.10	1.02	0.96	0.97	1.07
3	1.10	1.02	0.97	0.97	1.06
4	1.06	1.07	1.04	1.03	1.15
BIG	0.96	1.02	0.96	1.01	1.03

t(b)	LOW	2	3	4	HIGH
SMALL	39.23	50.60	58.42	57.99	57.76
2	53.20	58.56	59.98	62.77	63.25
3	59.68	56.81	53.35	58.93	51.14
4	57.16	52.61	50.34	51.30	46.30
BIG	57.20	56.98	42.80	55.04	37.70

s	LOW	2	3	4	HIGH
SMALL	1.40	1.27	1.16	1.10	1.19
2	1.00	0.94	0.83	0.71	0.85
3	0.70	0.63	0.54	0.45	0.65
4	0.30	0.27	0.25	0.22	0.36
BIG	(0.20)	(0.19)	(0.27)	(0.19)	(0.04)

t(s)	LOW	2	3	4	HIGH
SMALL	35.61	44.82	48.65	48.10	48.63
2	32.62	36.36	34.80	30.78	33.82
3	25.53	23.41	20.04	18.46	21.03
4	10.92	8.75	8.06	7.49	9.64
BIG	(8.10)	(7.08)	(7.99)	(6.91)	(1.05)

h	LOW	2	3	4	HIGH
SMALL	(0.30)	0.08	0.27	0.38	0.62
2	(0.48)	0.03	0.23	0.47	0.70
3	(0.43)	0.04	0.31	0.50	0.71
4	(0.44)	0.03	0.30	0.56	0.74
BIG	(0.44)	(0.02)	0.20	0.56	0.76

t(h)	LOW	2	3	4	HIGH
SMALL	(6.77)	2.43	9.92	14.93	22.43
2	(13.93)	0.88	8.73	18.32	24.74
3	(14.04)	1.39	10.27	18.28	20.34
4	(14.24)	0.79	8.77	16.68	17.79
BIG	(15.96)	(0.68)	5.25	18.41	16.65

Figure 1: Results of the Fama French 3 Factor Model

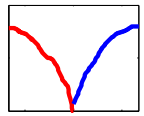


Table 6

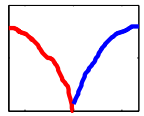
Regressions of excess stock and bond returns (in percent) on the excess market return ($RM-RF$) and the mimicking returns for the size (SMB) and book-to-market equity (HML) factors: July 1963 to December 1991, 342 months.[a]

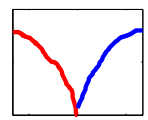
$$R(t) - RF(t) = a + b[RM(t) - RF(t)] + sSMB(t) + hHML(t) + e(t)$$

Dependent variable: Excess returns on 25 stock portfolios formed on size and book-to-market equity

Size quintile	Book-to-market equity (BE/ME) quintiles									
	Low	2	3	4	High	Low	2	3	4	High
	b					$t(b)$				
Small	1.04	1.02	0.95	0.91	0.96	39.37	51.80	60.44	59.73	57.89
2	1.11	1.06	1.00	0.97	1.09	52.49	61.18	55.88	61.54	65.52
3	1.12	1.02	0.98	0.97	1.09	56.88	53.17	50.78	54.38	52.52
4	1.07	1.08	1.04	1.05	1.18	53.94	53.51	51.21	47.09	46.10
Big	0.96	1.02	0.98	0.99	1.06	60.93	56.76	46.57	53.87	38.61
	s					$t(s)$				
Small	1.46	1.26	1.19	1.17	1.23	37.92	44.11	52.03	52.85	50.97
2	1.00	0.98	0.88	0.73	0.89	32.73	38.79	34.03	31.66	36.78
3	0.76	0.65	0.60	0.48	0.66	26.40	23.39	21.23	18.62	21.91
4	0.37	0.33	0.29	0.24	0.41	12.73	11.11	9.81	7.38	11.01
Big	− 0.17	− 0.12	− 0.23	− 0.17	− 0.05	− 7.18	− 4.51	− 7.58	− 6.27	− 1.18
	h					$t(h)$				
Small	− 0.29	0.08	0.26	0.40	0.62	− 6.47	2.35	9.66	15.53	22.24
2	− 0.52	0.01	0.26	0.46	0.70	− 14.57	0.41	8.56	17.24	24.80
3	− 0.38	− 0.00	0.32	0.51	0.68	− 11.26	− 0.05	9.75	16.88	19.39
4	− 0.42	0.04	0.30	0.56	0.74	− 12.51	1.04	8.83	14.84	17.09
Big	− 0.46	0.00	0.21	0.57	0.76	− 17.03	0.09	5.80	18.34	16.24

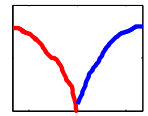
Figure 2: Results of the Fama French 3 Factor Model in Fama and French 1993b





Retrieving S&P 500 Data

Download the S&P 500 stocks from Yahoo finance

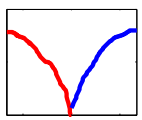


Retrieving SP500 Data

- Download S&P 500 adjusted stock prices

```
stocks<-BatchGetSymbols(tickers = companies$tickers,
                        first.date = "2010-01-01",
                        ast.date = "2017-12-31")

# Select the good tickers
good.tickers <- stocks$df.control$ticker [stocks$df.
  control$threshold.decision == "KEEP"]
```

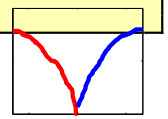
- stocks is a list that contains 2 dataframes:
  - df.control contains descriptive information
  - df.tickers contains the downloaded price data



Creating a data frame of S&P 500 Prices

- Use the dates of 3M as the date column of the data frame
- Merge price data of stocks into the data frame

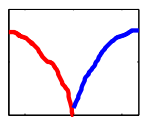
```
SP500.data <- data.frame(date = stocks$df.tickers[
  stocks$df.tickers$ticker == "MMM", "ref.date"])

for(i in 1:length(good.tickers)){
    X <- data.frame(
    stocks$df.tickers[stocks$df.tickers$ticker ==
      good.tickers[i], c("ref.date", "price.adjusted
      ")])
    colnames(X) <- c("date", as.character(good.
      tickers[i]))
    SP500.data <- merge.data.frame(SP500.data, X, by
       = "date", all.x = TRUE)
}
```



Convert daily data to monthly return

- Convert downloaded daily data to monthly price data series into XTS series
- quantmod::monthlyReturn()requires non-NA daily prices in xts format

```
1 Stock.Prices.Daily <- xts(Stock.Prices.Daily[,-1],
    order.by = as.POSIXct(Stock.Prices.Daily$date))
2
3 Stock.Prices.Daily <- Stock.Prices.Daily[!is.na(
    Stock.Prices.Daily)]
4
5 Stock.Prices.Monthly <- monthlyReturn(Stock.Prices.
    Daily)
```

Data Cleaning

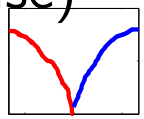
- **Removing stocks with NAs** in the series ensures that remaining stocks have same number of observations
- **Remove NAs in each series** results in a smaller sample size

Price data with NAs in the middle would result in inaccurate monthly returns.

(BHY Brighthouse Financial Inc. removed for 2015-2017 runs)

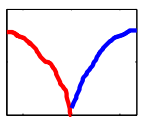
Here we face choices:

1. Remove all columns with NAs, then all remaining stocks could have the regression in the same period, i.e. with the same number of observations. (2010-2017)
2. Dynamically frame the data based on the available non-NA data points, but then some stocks in the regression analysis will have fewer observations. (1980-2015 every 5 years case)

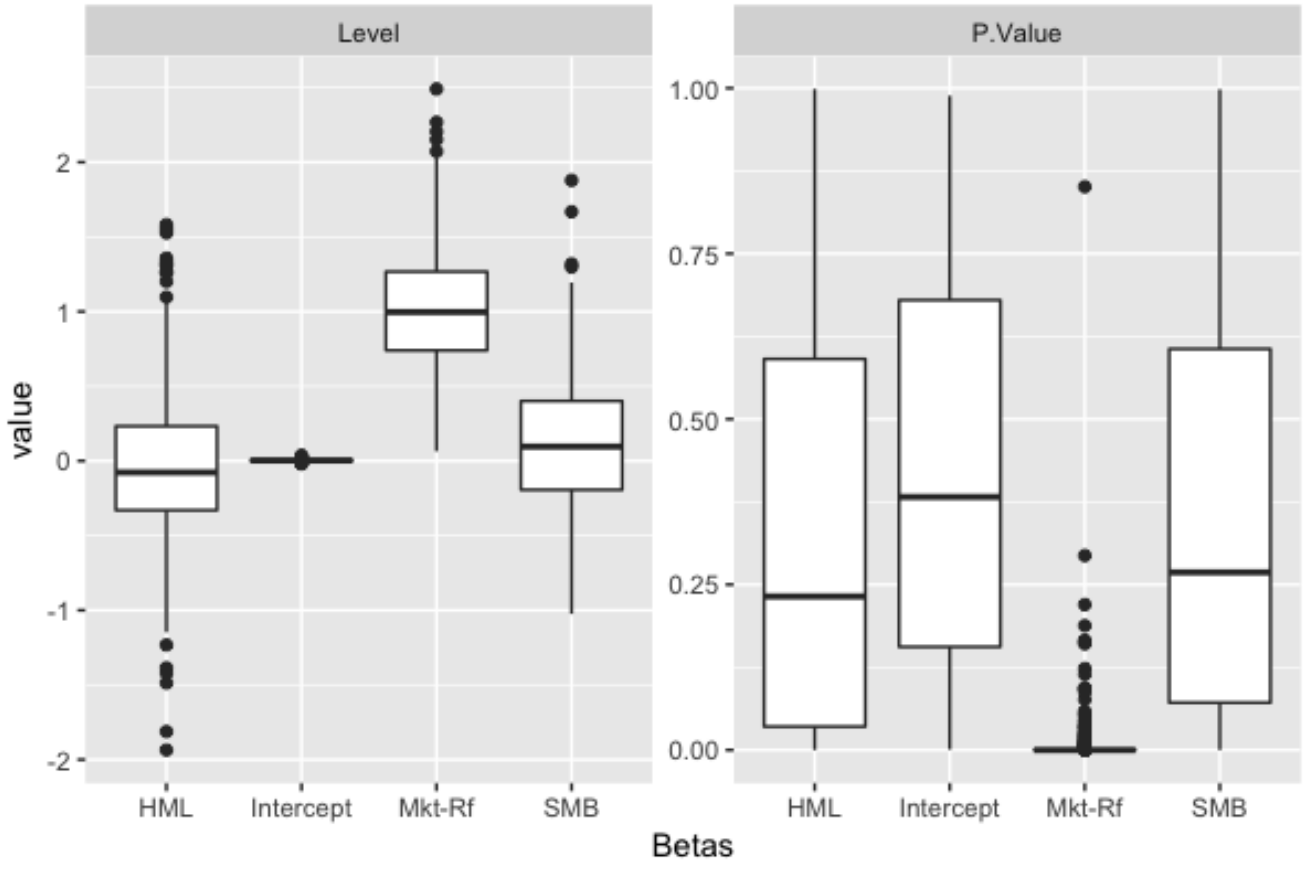


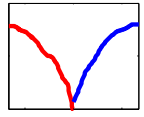
FamaFrench in 2010-2017

```
SP500.data <- read.csv("Data/SP500_price.
  adjusted_2010-2017.csv")
SP500.data$date <- as.Date(SP500.data$date)

# ...

Results <- list()
for(i in 1:ncol(Stock.Prices.Monthly)) {
  RiRF <- Stock.Prices.Monthly[,i] - FF$RF
  Regression <- lm(RiRF ~ FF$Mkt.RF + FF$SMB +
    FF$HML)
  Results[[i]] <- summary(Regression)
}
```

Boxplot of the regression results

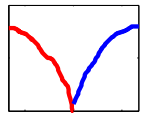




Goodness of Fit

	Ticker	Name	Sector	R.Squared
388	TROW	T. Rowe Price Group	Financials	0.6806
227	IVZ	Invesco Ltd.	Financials	0.6777
31	AMG	Affiliated Managers Group Inc	Financials	0.6646
283	MS	Morgan Stanley	Financials	0.6334
334	PRU	Prudential Financial	Financials	0.6308
201	HON	Honeywell Int'l Inc.	Industrials	0.6299
270	MET	MetLife Inc.	Financials	0.6279
321	PFG	Principal Financial Group	Financials	0.6262
60	BEN	Franklin Resources	Financials	0.6225
232	JPM	JPMorgan Chase & Co.	Financials	0.6027

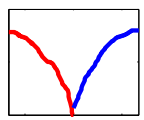
Figure 3: This table needs to be updated!



Trend analysis in 1980-2015

- loop over above codes to download data from 1980 - 2015, group every 5 years

```
1 library(lubridate)
2 List.of.start.date <- seq(as.Date("1980/1/1"), as.
    Date("2016/1/1"), "years")
3 List.of.start.date <- List.of.start.date[year(List.
    of.start.date)%%5==0]
```

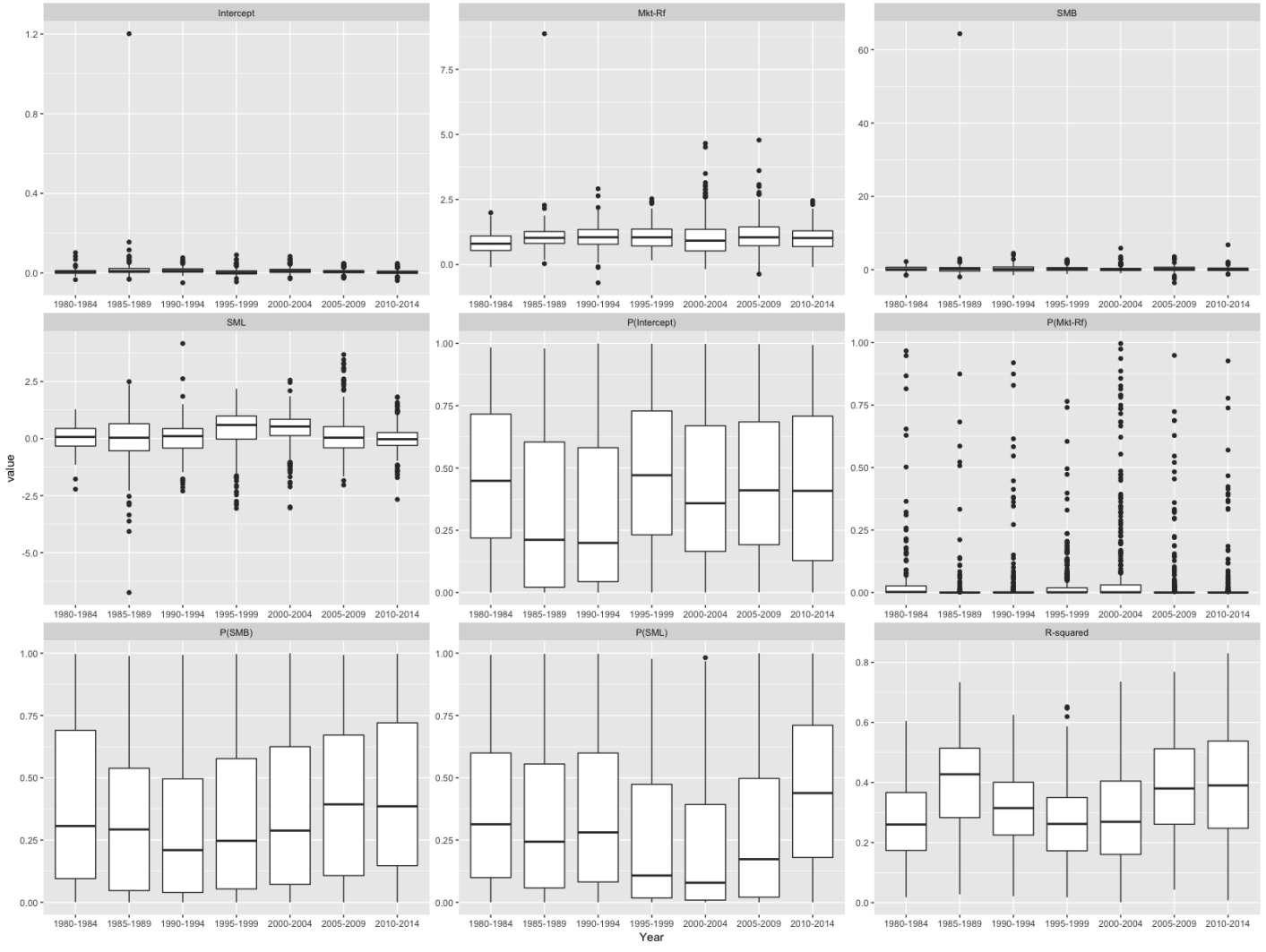
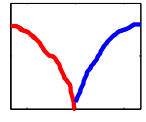


Figure 4: Trend analysis in 1980-2015 of full sample



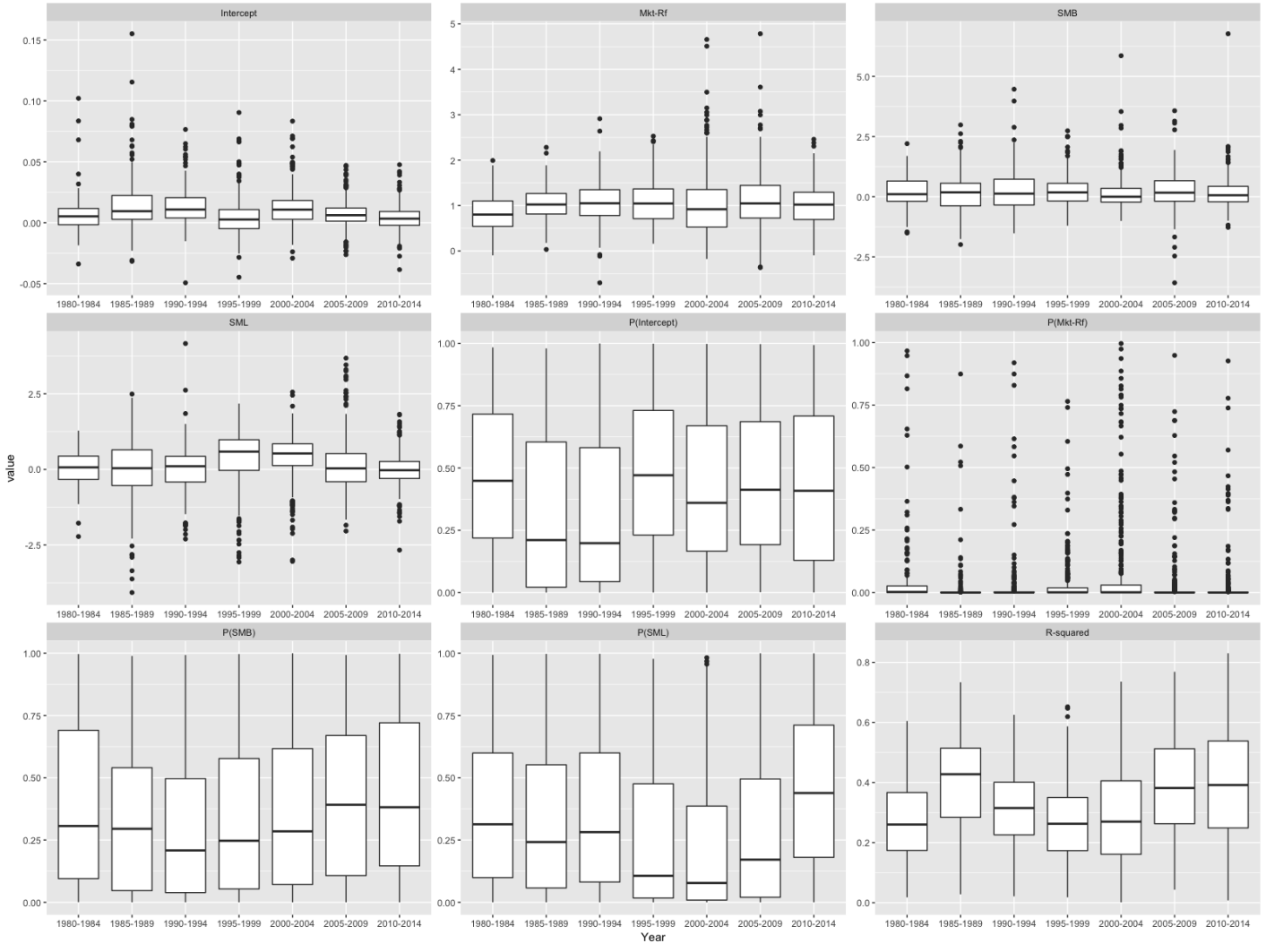
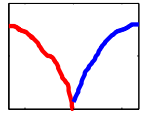


Figure 5: Trend analysis in 1980-2015 without MNST



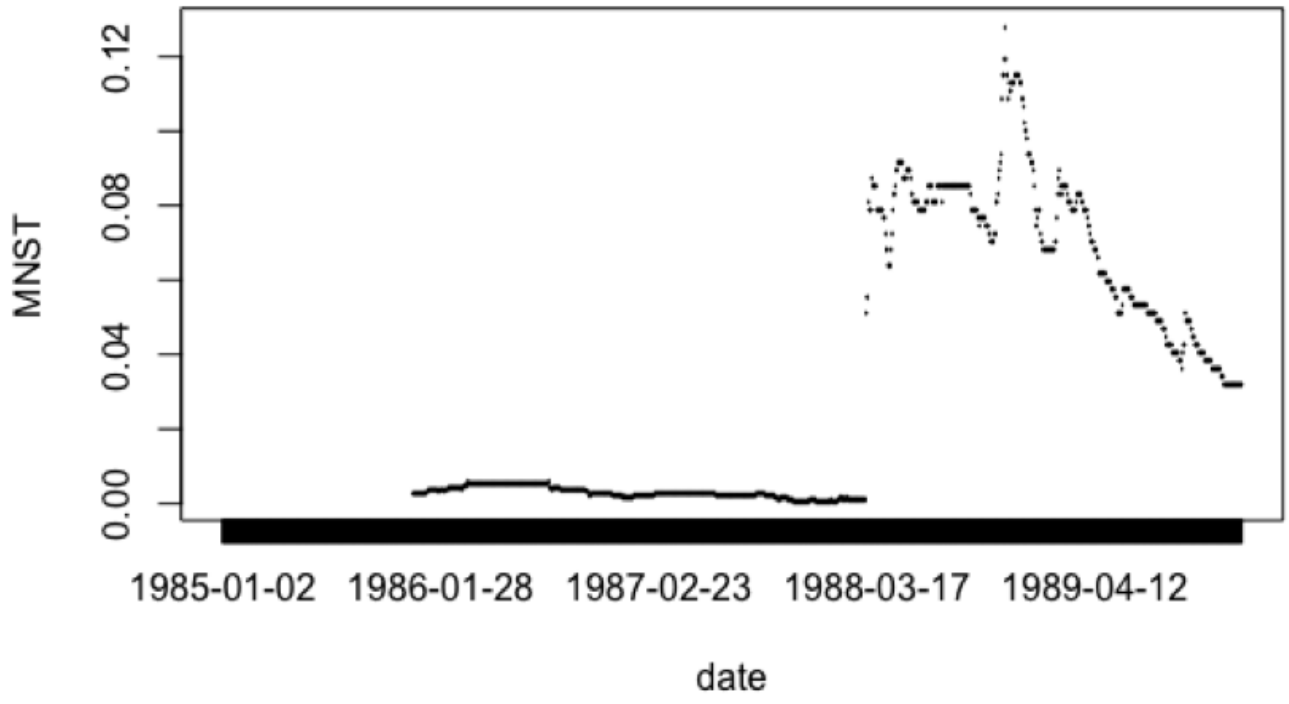
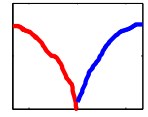


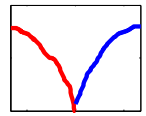
Figure 6: Monthly Return of MNST (Monster Beverage Corp)



Varying Samples

Time Period	Number of Stocks
1980-1984	170
1985-1989	229
1990-1994	271
1995-1999	345
2000-2004	394
2005-2009	432
2010-2014	459

Figure 7: Varying Samples: Sample sizes in each time period



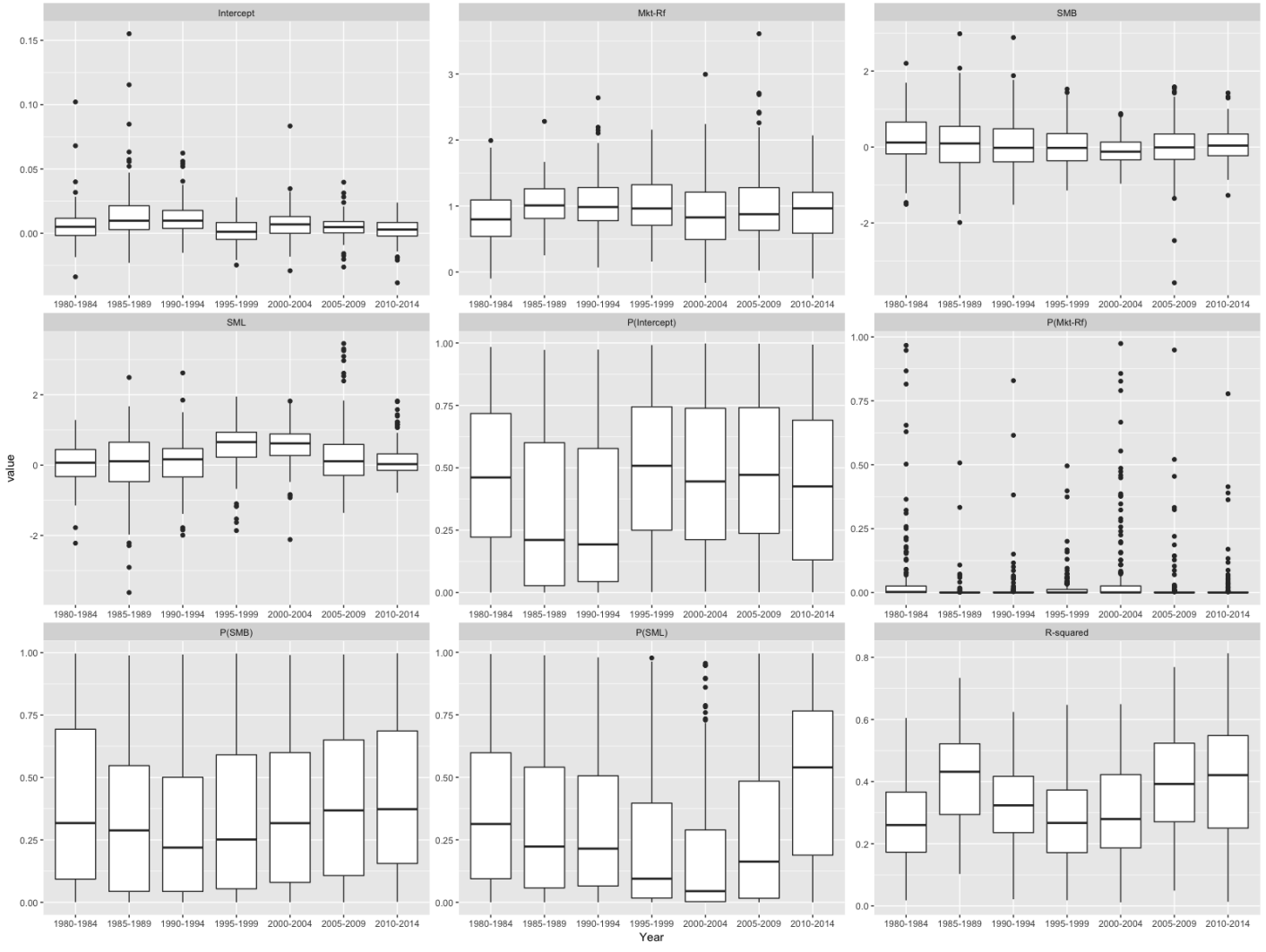
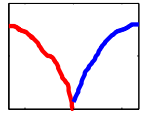


Figure 8: Trend analysis of 168 stocks listed from 1980-2015



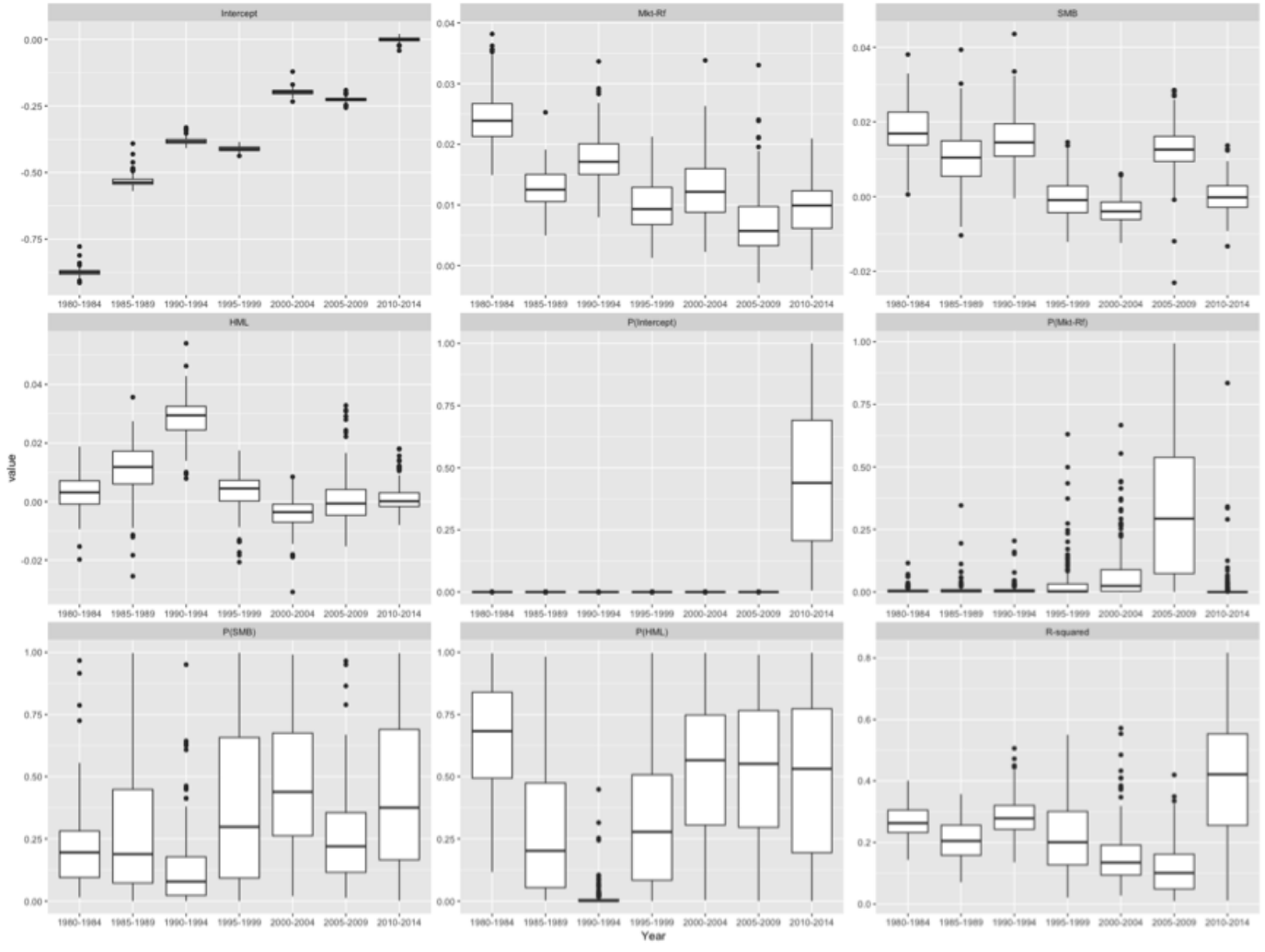
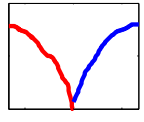


Figure 9: 168 Stocks idk what else



Correlation of The factors and Top 20 and Bottom 20 returns

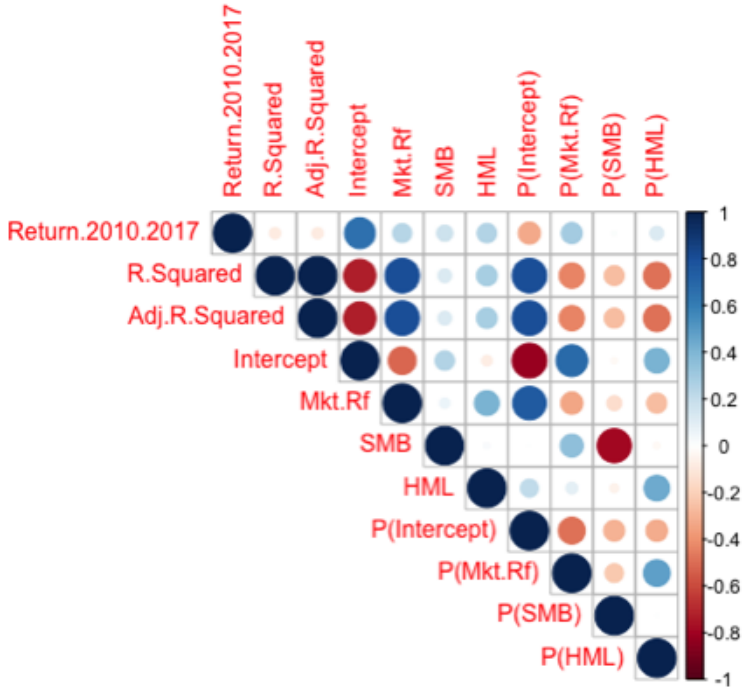


Figure 10: Top 20

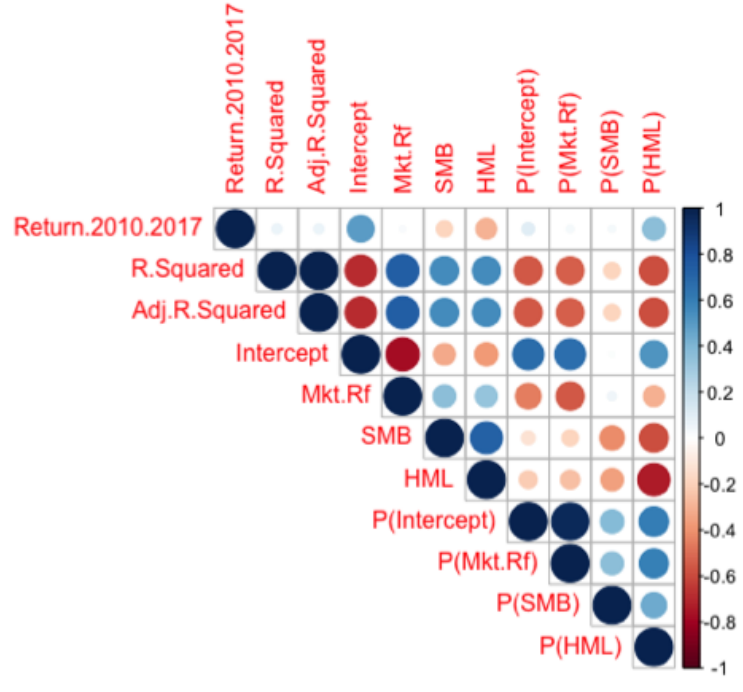
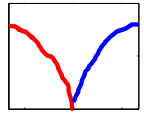


Figure 11: Bottom 20



Conclusion