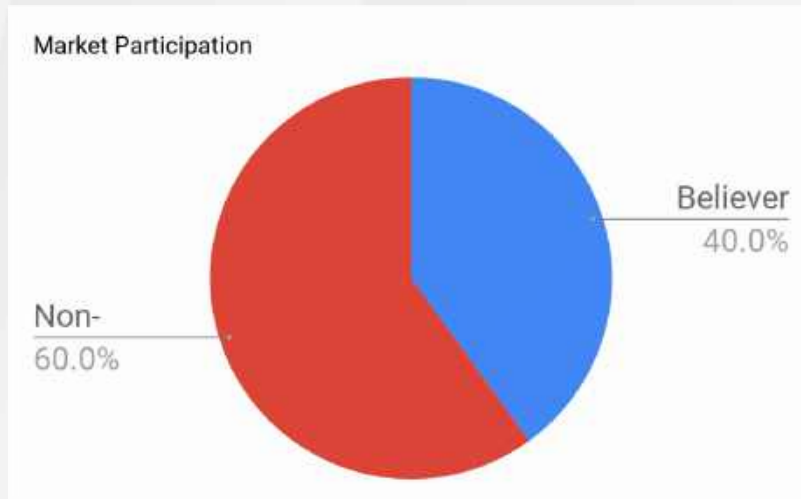# BACKTESTING

3 Technical Factors

Team Members: Jingsi Xu, Luhao Wang, Xunshen Chen, Muqing Xiong
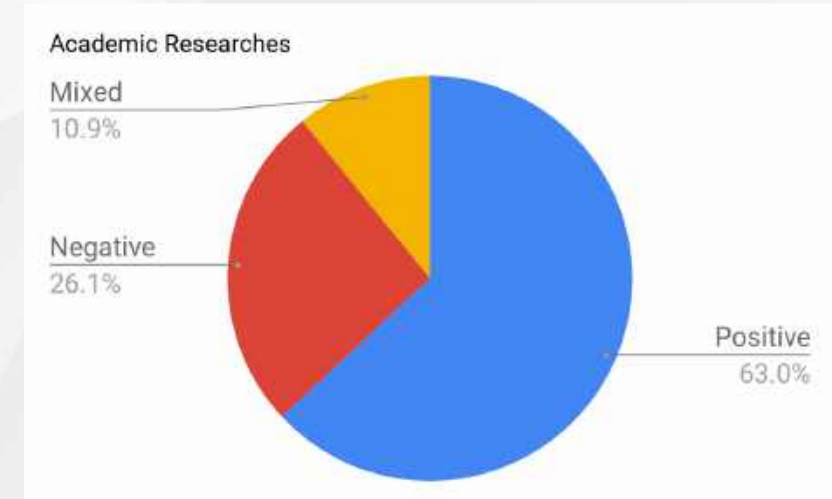
Project Purpose

Backtesting on **22 firm-characteristics factors** including **3 technical factors**.

Why technical factors?

Market Participation

Believer 40.0%

Non- 60.0%

Academic Researches

Mixed 10.9%

Negative 26.1%

Positive 63.0%

About **40%** of market practitioners appear to believe that technical analysis is an important factor in determining price movement.

From 1990s, more studies were on profitability of technical factors in stock market. Among a total of **92** modern studies, **58** studies found positive results regarding technical trading strategies, while **24** studies obtained negative results. 10 studies indicated mixed results.

References:
1. Firm Characteristics and Empirical Factor Models: A Data-Mining Experiment, Author: Leonid Kogan and Mary Tian.
2. Technical Analysis in Financial Markets, Prof. dr C.H. Hommes, and Prof. dr H.P. Boswijk
3. The Profitability of Technical Analysis: A Review, Cheol-Ho Park and Scott H. Irwin

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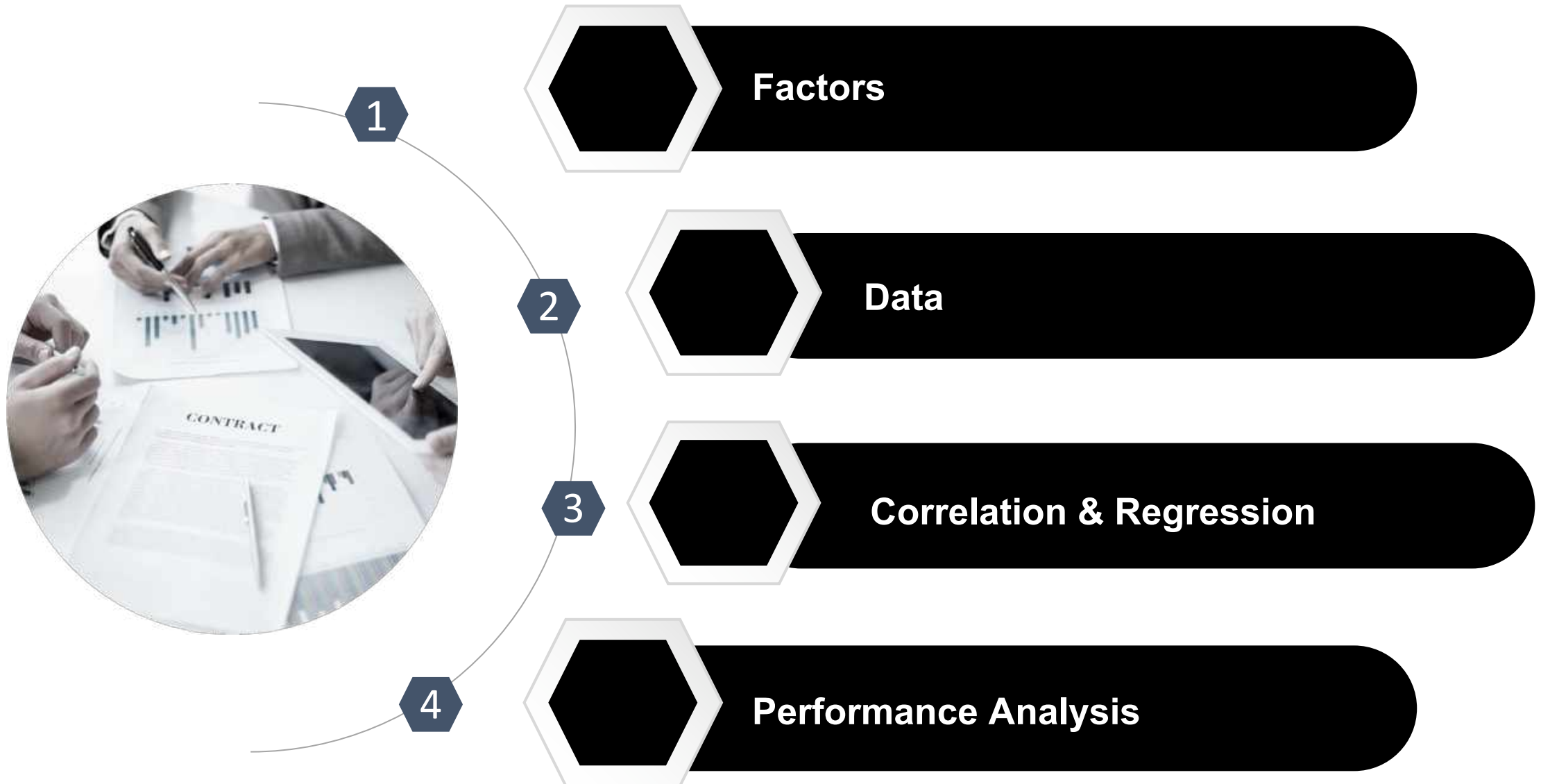
Technical Factors - Theory

RSI
Relative Strength Index

The RSI was originally developed by **J. Welles Wilder Jr.** and introduced in **1978**

A momentum indicator to evaluate **overbought** or **oversold** conditions in the stock price by measuring the magnitude of recent price changes.

Above 70 —— overbought
Below 30 —— oversold

MACD
Moving Average Convergence Divergence

The MACD was created by **Gerald Appel** in the **late 1970s**.

A trend-following momentum that shows the relationship between short and long term moving average of a security's price, revealing changes in the strength, direction, momentum, and duration of a trend in a stock's price.

crosses above SL —— buy
crosses below SL —— sell

BBP%
Bollinger bands%

The BBP was created by **John Bollinger,** by famous technical trader,in the **early 1980's**

It measures percentage of two standard deviations (positively and negatively) away from a simple moving average (SMA) of the security's price. BBP considers not only the moving trend but also the volatility of the stock.

Technical Factors - Calculation

PS: One week as a period

RSI

1st Step: Calculate UC/DC

Up Closes at time t $(UC_t) = P_t^c - P_{t-1}^c$, if $P_t^c > P_{t-1}^c$.

Down Closes at time t $(DC_t) = -(P_t^c - P_{t-1}^c)$, if $P_t^c < P_{t-1}^c$.

2ed Step: Average Up Closes over 42 weeks at each time point

$$AUC_t = \sum_{i=1}^{n} UC_{t-i+1}/n, \quad AUC_{t+1} = (AUC_t \times (n-1) + UC_{t+1})/n,$$

$$AUC_{t+2} = (AUC_{t+1} \times (n-1) + UC_{t+2})/n, \quad ....$$

3rd Step: Average Down Closes over 42 weeks at each time point

$$ADC_t = \sum_{i=1}^{n} DC_{t-i+1}/n, \quad ADC_{t+1} = (ADC_t \times (n-1) + DC_{t+1})/n,$$

$$ADC_{t+2} = (ADC_{t+1} \times (n-1) + DC_{t+2})/n, \quad ....$$

4th Step: Calculate RSI

Relative Strength at time t $(RS_t) = AUC_t / ADC_t$.

Relative Strength Index at time t $(RSI_t) = 100 - (100/(1 + RS_t))$.

	PERMNO	date	PRC	year	Date	weekday	month	UC	DC	AUC	ADC	RSI
41	10001	19900427	10.0000	1990	1990-04-27	5	4	19.8750	0.0000	NaN	NaN	NaN
42	10001	19900504	9.7500	1990	1990-05-04	5	5	0.0000	0.2500	1.899709	1.867733	50.424383
43	10001	19900511	9.8750	1990	1990-05-11	5	5	0.0000	0.1250	1.855530	1.827204	50.384580

BBP%

$$BBP[t] = \frac{price[t] - SMA[t](20P)}{2 \cdot STD[t](20P)}$$

$$SMA[t] = \frac{\sum_{i=today}^{i=today-n} Price[i]}{n} = price[t-n:t].mean()$$

MACD

1st Step: Calculate MACD

$$MACD[t] = EMA[t](12P) - EMA[t](26P)$$

$$EMA[t] = \left(Price[t] * \frac{2}{1+n}\right) + EMA[t-1] * \left(1 - \frac{2}{1+n}\right)$$

2ed Step: Set signal line

$$Signal\ Line[t] = \left(MACD[t] * \frac{2}{1+9}\right) + Signal\ Line[t-1] * \left(1 - \frac{2}{1+9}\right)$$

3rd Step:

$MACD$ - $Signal\ Line$

Initial Factors (3+19)

Category		Name	Expected Sign	Literature
Technical(3)	RSI	Relative Strength Index	+	Wilder(1978)
	MACD	Moving Average Convergence Divergence	+	Gerald Appel(late 1970s)
	BBP	Bollinger bands%	-	John Bollinger(early 1980s)
Valuation(2)	EP	Earnings-to-Price	+	Fama, E. F. and French (1996)
	lnSIZE	ln of Market Cap	-	Banz (1981)
Investment(4)	IA	Investment-to-Asset	-	Lyandres, Sun, and Zhang (2008)
	IG	Investment Growth	-	Xing, Y. (2008)
	IK	Investment-to-Capital	-	Xing, Y. (2008)
	NOA	Net Operating Assets	-	Hirshleifer, Hou, Teoh, and Zhang (2004)
Prior Returns(2)	MOM	Momentum	+	Jegadeesh and Titman (1993)
	LTR	Long-Term Reversal	-	DeBondt and Thaler (1985)
Financial Distress(2)	OS	Ohlson score (Financial Distress)	-	Soohun Kim and Georgios Skoulakis(2018)
	LEV	Market Leverage	+	Bhandari (1988)

Initial Factors (3+19)

Category		Name	Expected Sign	Literature
Earning(4)	ROA	Return-on-Assets	+	Chen et al. (2010)
	ROE	Return-on-Equity	+	Gompers, and Vuolteenaho (2002)
	SG	Sales Growth	+	Lakonishok, Shleifer, and Vishny (1994)
	SUE	Standardized unexpected earning	+	Ball, R. and P. Brown (1968)
	InSIZE	In of Market Cap	-	Banz (1981)
Earning Financing(2)	CI	Composite Insurance	-	Daniel, K. and S. Titman (2006)
	NS	Net Stock Issue	-	Fama, E. F. and K. French (1993)
Other(3)	TO	Turnover Ratio	-	Lee, C. M. and B. Swaminathan (2000)
	OK	Organizational Capital	+	Eisfeldt and Papanikolaou (2012)
	BETA	Market Beta	-	Frazzini and Pedersen (2011)

Data Cleaning

Steps

1. Gather: data from "WRDS" & "27 factors data package";
2. Merge: all data of available factors by "year" & "PERMNO";
3. Recalculate: pick mid-year data, compute the mean of each window year from monthly data, Z-Scores by industry
4. Clean: delete insufficient data factors, omit NA;
5. Reconstructure: separate data into in-sample data (1990.6-2008.6) and out-of-time data (2009.6-2016.6).

Results of raw data

4488 unique stocks of 26 years (1990.6 - 2016.6),
with 34,560 observations and 27 variables (760,000+ points)

Correlation Analysis

```
> which(correlation[["r"]]>=0.5, arr.ind = T)
```

	row	col
zEP	1	1
zIA	2	2
zIG	3	3
zIK	4	4
zLEV	5	5
zNOA	6	6
zNS	7	7
zOK	8	8
zROA	9	9
zROE	10	10
zlnSIZE	11	11
zMOM	12	12
zOS	13	13
zSG	14	14
zSUE	15	15
zBETA	16	16
zCI	17	17
zLTR	18	18
zTO	19	19
zRSI	20	20
zMACD	21	21
BBP	22	22
RET	23	23
```
>
```

```
> which(correlation[["p"]] < 0.05, arr.ind = T)
```

	row	col
zEP	1	1
zIA	2	1
zIK	4	1
zLEV	5	1
zNS	7	1
zOK	8	1
zROA	9	1
zROE	10	1
zlnSIZE	11	1
zMOM	12	1
zOS	13	1
zSG	14	1
zSUE	15	1
zBETA	16	1
zCI	17	1
zLTR	18	1
zTO	19	1
zRSI	20	1
zMACD	21	1
RET	23	1
zIA	2	2
zIG	3	2
zIK	4	2
zLEV	5	2
zNOA	6	2

remove features has high correlation(>=0.5) with high significance(<0.05)

In the Sample Estimation(1990-2008)

NAME	COEFFICIENTS	expected sign	FM_TSTATISTCS
zEP	0.001286098	+	0.21967143
zIA	-0.002882020	-	-0.50462618
zIG	-0.003407888	-	-1.00510845
zIK	-0.000352863	-	-0.09784048
zLEV	0.013965996	+	2.28774702
zNOA	-0.006840441	-	-1.20916239
zNS	-0.007240278	-	-2.59537771
zOK	0.005756759	+	1.83428519
zROA	-0.000447843	+	-0.06632511
zROE	-0.001228424	+	-0.23048121

In the Sample Estimation(1990-2008)

NAME	COEFFICIENTS	expected sign	FM_TSTATISTCS
zlnSIZE	-0.010658738	-	-1.21180529
zMOM	0.006532899	+	1.06557499
zOS	-0.009861766	-	-1.54800991
zSG	0.008082607	+	1.50900709
zSUE	0.006245376	+	1.53571894
zBETA	-0.002098057	-	-0.35707096
zCI	0.002547513	-	0.60937373
zLTR	-0.006177293	-	-1.44445478
zTO	-0.002148257	-	-0.30214887
zRSI	0.004535160	+	0.65822182
zMACD	-0.007004227	+	-1.39627204
BBP	-0.049184308	-	-1.36567766

Out of Sample(2009-2016)

Year	Month	Long Ret	Short Ret	Port. Ret (L-S)
2009	7	10.32%	9.50%	0.82%
2009	8	3.49%	2.78%	0.71%
2009	9	7.37%	8.10%	-0.72%
2009	10	-4.02%	-5.29%	1.27%
2009	11	4.67%	4.48%	0.19%
………………	.			
2017	2	0.68%	1.65%	-0.97%
2017	3	1.66%	1.43%	0.23%
2017	4	1.97%	2.68%	-0.71%
2017	5	-2.32%	-0.37%	-1.96%
2017	6	2.54%	3.10%	-0.57%

Performance Evaluation

Performance of Long-Short Portfolio
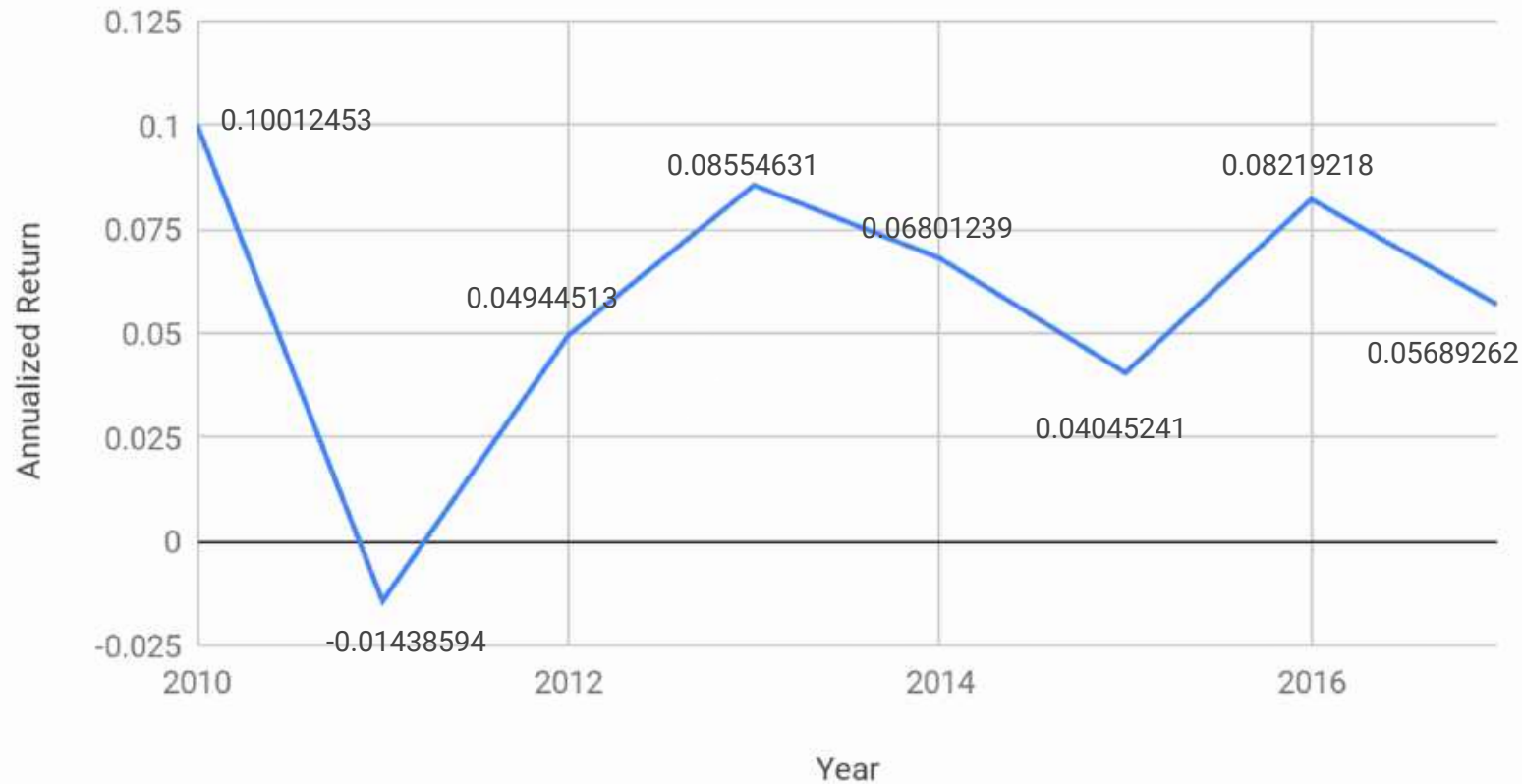
Performance Measure	Value
Monthly Mean return	0.48%
Annualized mean return	5.85%
Annualized Sharpe Ratio	1.057689
CAPM Alpha	0.005833
FF 3 Factor alpha	0.005742
Corhart 4 Factor Alpha	0.005756
Annualized IR	1.286294

Conclusion

- With 5.85% average annualized return and 1.058 annualized Sharpe Ratio, our model is profitable although further research about taxes, transaction fee, and market impact is needed.

- Technical factors tend to have smaller t-statistics in regression over 1990-2008. Momentum factor is even not picked in our final model.

- Future work to improve our model. (1)For technical indicators, use shorter moving window with short-term return, and rebalance our portfolio dynamically. (2)Add Macro Factors (like GDP, inflation, etc) and Alternative Factors (like star analyst recommendations, insider purchase, behavioral factors etc) in the future study.

THANK YOU

Correlation Analysis

Factor	Expected Sign	T-stat	Factor	Expected Sign	T-stat
zRSI	+	2.158	zROA	+	-2.124
zMACD	+	-1.921	zROE	+	-1.035
BBP	-	-0.597	zlnSIZE	-	-1.972
zEP	+	3.112	zMOM	+	3.087
zIA	-	-3.056	zOS	-	-0.778
zIG	-	-2.387	zSG	+	-0.215
zIK	-	-2.096	zSUE	+	3.087
zLEV	+	4.380	zBETA	-	-1.238
zNOA	-	-3.932	zCI	-	-1.926
zNS	-	-3.507	zLTR	-	-3.574
zOK	+	2.855	zTO	-	-2.327