



# **Exploring the EG Algorithm Across Different Sectors of the Market**

*Researched and presented by Nick Kurtansky, Karen Semrau, and Rob Gerth  
MSU Spring 2018 - STT 481 - Capstone Project*

# Focus: Exploring the Exponential Gradient Algorithm Across Industries

- How does a return on investment using EG compare to both individual stocks and the best constant rebalanced portfolio?
- Across each sector of the market, how does varying the eta value affect performance?
- In a real world with transaction fees, how applicable is the algorithm as an investment tool?



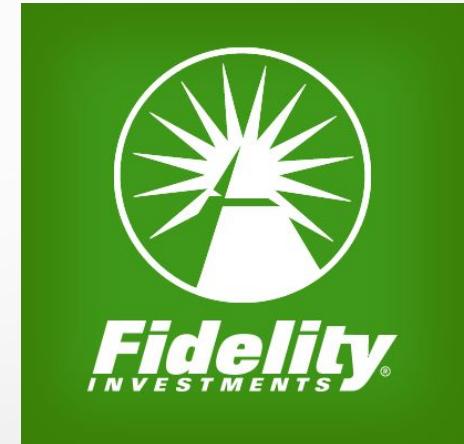
# Terminology

- **Stock Market:** collection of markets and exchanges where issuing and trading of equity, bonds, and other securities occurs
- **Industry:** Set of businesses that are producing such similar goods and services that they are in direct competition with each other
- **Stock:** Measure of equity, or partial ownership of a company
- **Diversify:** Method of risk management that mixes a variety of investment types.
- **Portfolio:** Grouping of financial assets



# Terminology

- **Transaction Fee:** A per-transaction fee charged by stock brokers for their services
  - Fidelity - \$4.95
- **Investment Period:** we are investing over a 10-year period
  - January 2008 - January 2018
- **Growth Period:** the time over which you allow your stock to gain interest.
  - We set this for 30 days => trading monthly



# We compared 5 sectors of the market:

- Finance
- Healthcare
- Transportation
- Technology
- Energy



# Company Group: Finance

Symbol	Name	Sector	Industry
BMA	Macro Bank Inc.	Finance	Commercial Banks
MSL	MidSouth Bancorp	Finance	Major Banks
VLY	Valley National Bancorp	Finance	Major Banks
INTL	INTL FCStone Inc.	Finance	Investment Bankers/Brokers/Service
FNCB	FNCB Bancorp Inc.	Finance	Major Banks
WAFD	Washington Federal, Inc.	Finance	Major Banks
WRB	W.R. Berkley Corporation	Finance	Property-Casualty Insurers
WSBF	Waterstone Financial, Inc.	Finance	Savings Institutions
CRVL	CorVel Corp.	Finance	Specialty Insurers
CIA	Citizens, Inc.	Finance	Life Insurance

# Company Group: Healthcare

Symbol	Name	Sector	Industry
AKRX	Akorn, Inc.	Health Care	Major Pharmaceuticals
RMTI	Rockwell Medical, Inc.	Health Care	Biotechnology: Electromedical & Electrotherapeutic Apparatus
ANIK	Anika Therapeutics Inc.	Health Care	Medical/Dental Instruments
RELV	Reliv International, Inc.	Health Care	Major Pharmaceuticals
PMD	Psychemedics Corporation	Health Care	Medical Specialities
DGX	Quest Diagnostics Incorporated	Health Care	Medical Specialities
ATRS	Antares Pharma, Inc.	Health Care	Medical/Dental Instruments
ALQA	Alliqua BioMedical, Inc.	Health Care	Medical/Dental Instruments
OGEN	Oragenics Inc.	Health Care	Major Pharmaceuticals
SGEN	Seattle Genetics, Inc.	Health Care	Biotechnology: Biological Products (No Diagnostic Substances)

# Company Group: Transportation

Symbol	Name	Sector	Industry
GWR	Genesee & Wyoming, Inc.	Transportation	Railroads
JBLU	JetBlue Airways Corporation	Transportation	Air Freight/Delivery Services
LUV	Southwest Airlines Company	Transportation	Air Freight/Delivery Services
SAIA	Saia, Inc.	Transportation	Trucking Freight/Courier Services
LSTR	Landstar System, Inc.	Transportation	Trucking Freight/Courier Services
KNX	Knight Transportation, Inc.	Transportation	Trucking Freight/Courier Services
ESEA	Euroseas Ltd.	Transportation	Marine Transportation
ODFL	Old Dominion Freight Line, Inc.	Transportation	Trucking Freight/Courier Services
CVTI	Covenant Transportation Group, Inc.	Transportation	Trucking Freight/Courier Services
FDX	FedEx Corporation	Transportation	Air Freight/Delivery Services

# Company Group: Technology

Symbol	Name	Sector	Industry
SLP	Simulations Plus, Inc.	Technology	EDP Services
STX	Seagate Technology PLC	Technology	Electronic Components
AAPL	Apple Inc.	Technology	Computer Manufacturing
MANH	Manhattan Associates, Inc.	Technology	Computer Software: Prepackaged Software
RBCN	Rubicon Technology, Inc.	Technology	Semiconductors
VMW	Vmware, Inc.	Technology	Computer Software: Prepackaged Software
FORM	FormFactor, Inc.	Technology	Semiconductors
SINA	Sina Corporation	Technology	Computer Software: Prepackaged Software
GHM	Graham Corporation	Technology	Industrial Machinery/Components
OSIS	OSI Systems, Inc.	Technology	Semiconductors

# Company Group: Energy

Symbol	Name	Sector	Industry
OIS	Oil States International, Inc.	Energy	Metal Fabrications
CVX	Chevron Corporation	Energy	Integrated oil Companies
AREX	Approach Resources Inc.	Energy	Oil & Gas Production
XOM	Exxon Mobil Corporation	Energy	Integrated oil Companies
PAA	Plains All American Pipeline, L.P.	Energy	Natural Gas Distribution
AHGP	Alliance Holdings GP, L.P.	Energy	Coal Mining
GE	General Electric Company	Energy	Consumer Electronics/Appliances
CPST	Capstone Turbine Corporation	Energy	Industrial Machinery/Components
MRO	Marathon Oil Corporation	Energy	Oil & Gas Production
WLL	Whiting Petroleum Corporation	Energy	Oil & Gas Production

# Exponential Gradient Algorithm (EG)

- Method: Initially invest with equal weights into a set of companies. At the end of each growth period, sell all equity and immediately purchase stock according to adjust weights which are calculated by time-weighted interest and a reactionary parameter eta.
- Eta: **reactionary/greediness parameter**
  - High Eta => reacts quickly to changes in the market
  - Low Eta => reacts slowly to changes in the market
- Pro: Algorithm *learns* about the market over time & adjusts accordingly
- Con: Broker fees will add up *very* quickly
  - Total Broker Fees =  $2 * \$4.95 * 10 \text{ companies} * [(10 \text{ years} * 12 \text{ months}) - 1] = \$11,781$



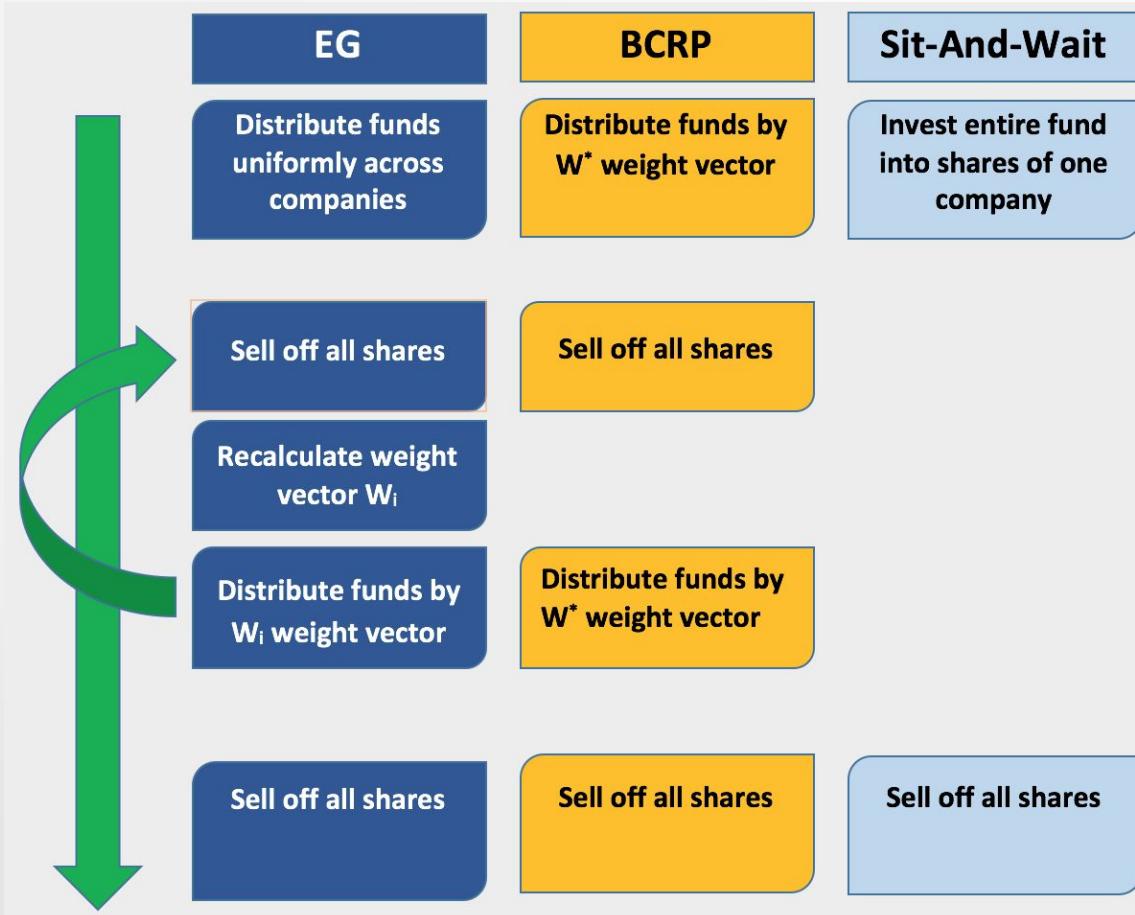
# The Sit-and-Wait Method

- Method: Purchasing shares at the beginning of the investment period (Jan 2008), holding them for 10 years, and then selling at the new market price (Jan 2018)
- Pro: Broker fees are minuscule
- Con: Rather than diversifying, you are making an *all in* investment which is risky
- Total Broker Fees =  $\$4.95 * 2 = \$9.90$

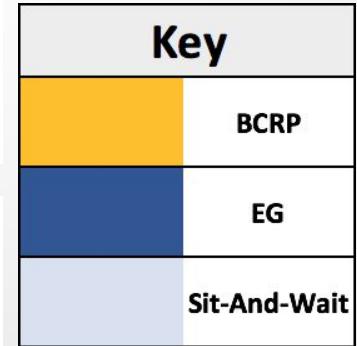
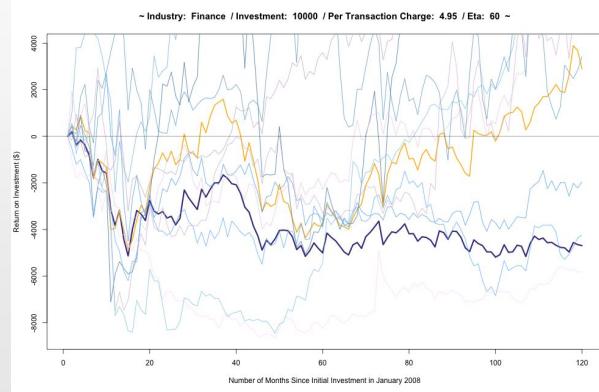
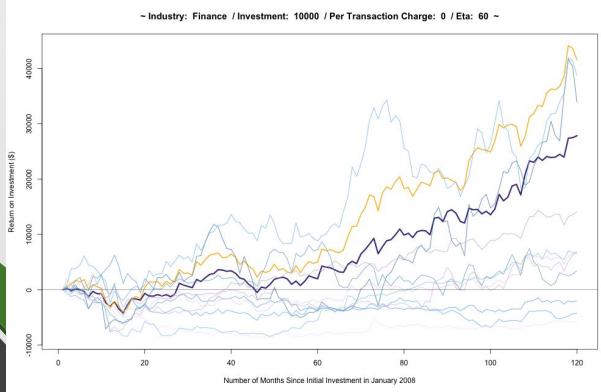
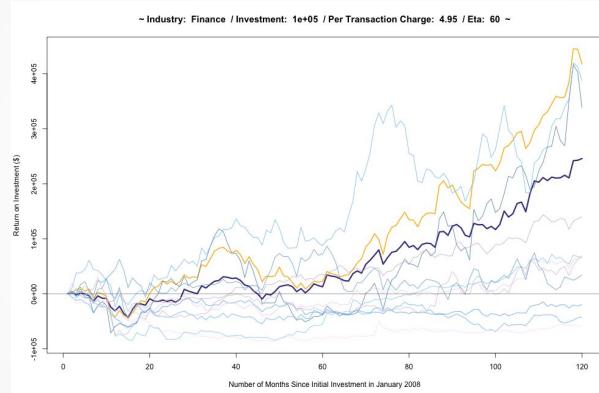
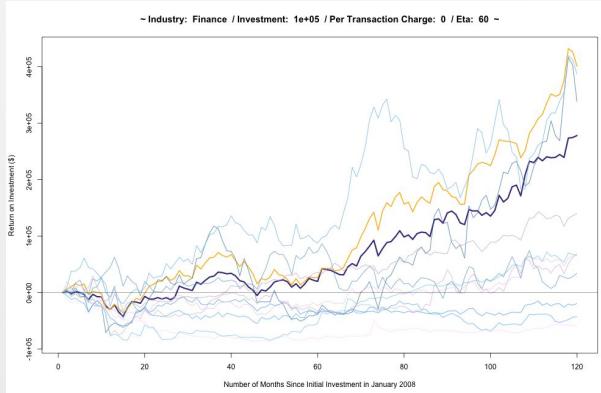
# Best Constant Rebalanced Portfolio (BCRP)

- Because it is based on retrospective data, it is not itself a strategy, but rather a point of comparison for the other methods.
  - Consider it the **Gold Standard**
- Method: calculate the optimal set of weights, and divide fortune according to those weights at each trading period.
- Outperforms EG and Sit-and-Wait methods when broker fees are not considered
  - Is not always as successful as the best stock when considering transaction fees
- Total Broker Fees = \$11,781

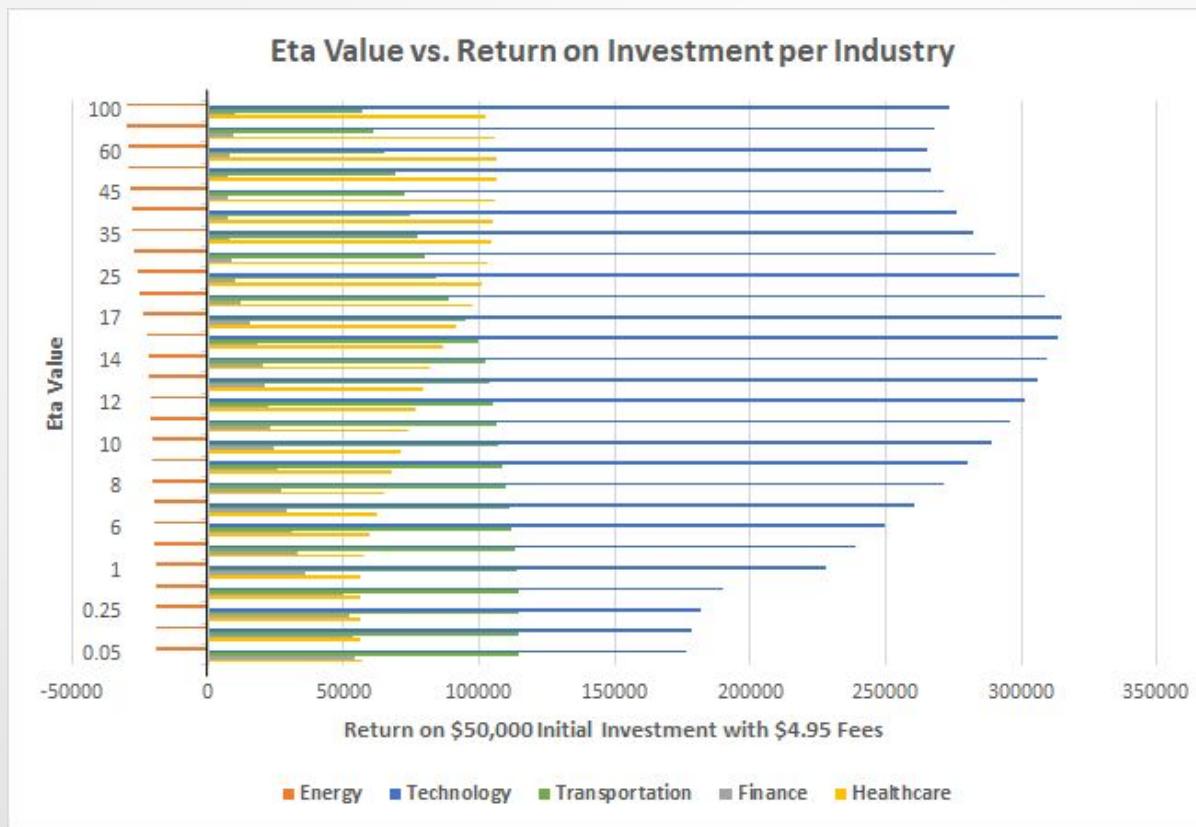
# Algorithm Flow chart



# Performance with & without service charge (\$4.95/trade)

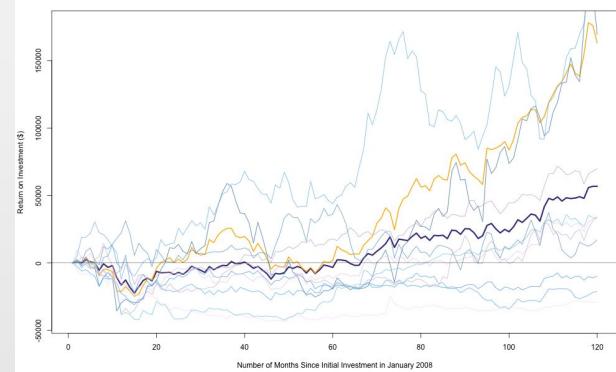


# What eta values are ideal in each industry?

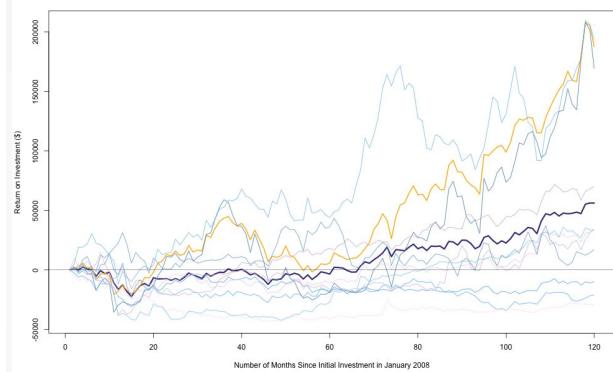


# Finance

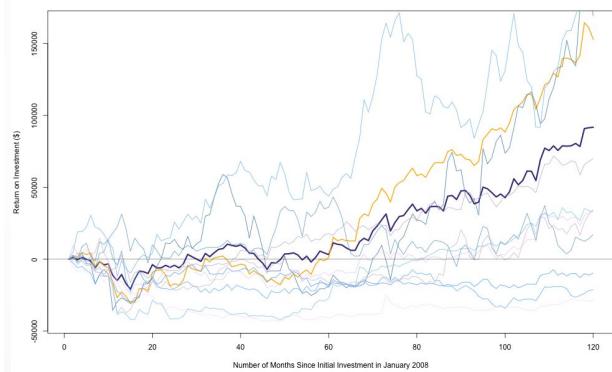
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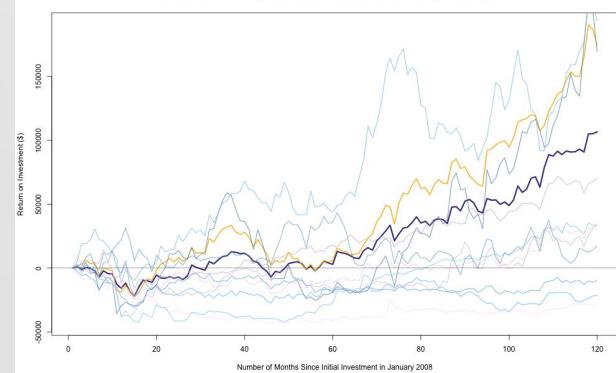
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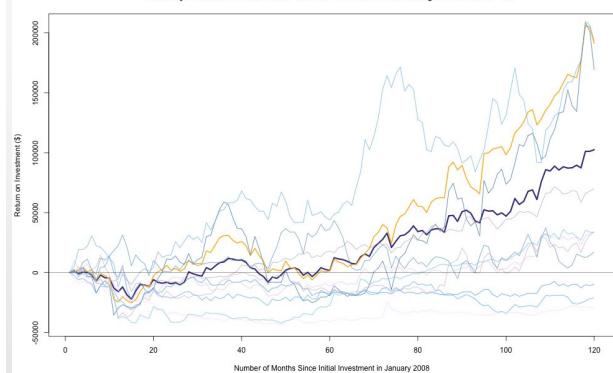
- Industry: Finance / Investment: 50000 / Per Transaction Charge: 4.95 / Eta: 20 ~



- Industry: Finance / Investment: 50000 / Per Transaction Charge: 4.95 / Eta: 60 ~



- Industry: Finance / Investment: 50000 / Per Transaction Charge: 4.95 / Eta: 150 ~



**Key**

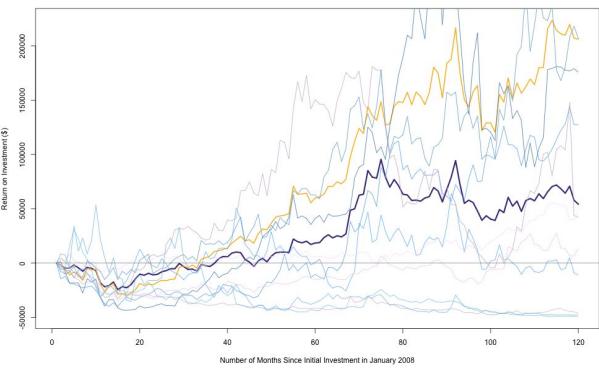
**BCRP**

**EG**

**Sit-And-Wait**

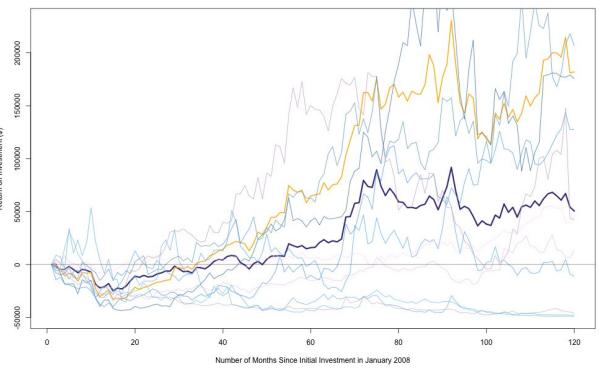
# Healthcare

- Industry: Healthcare / Investment: 50000 / Per Transaction Charge: 4.95 / Eta: 0.05 ~

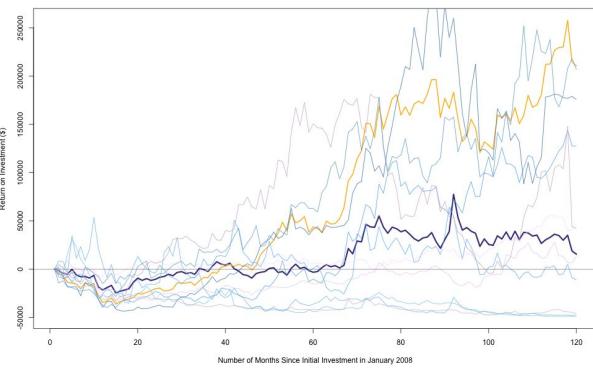


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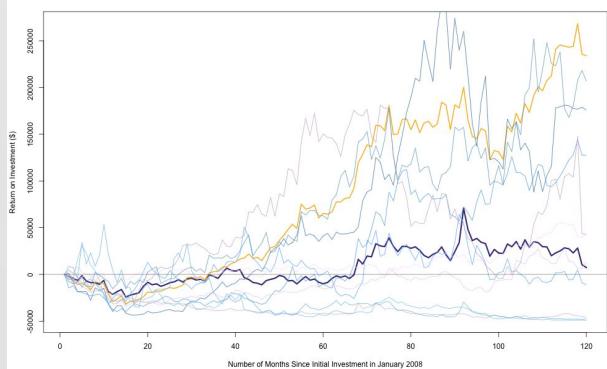
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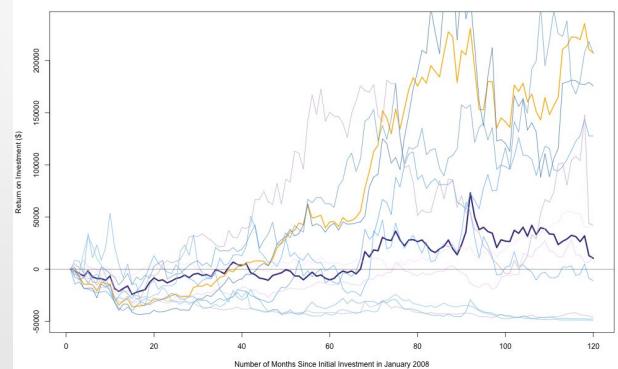
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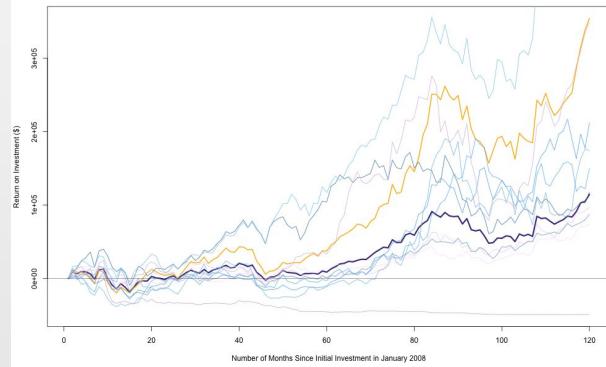
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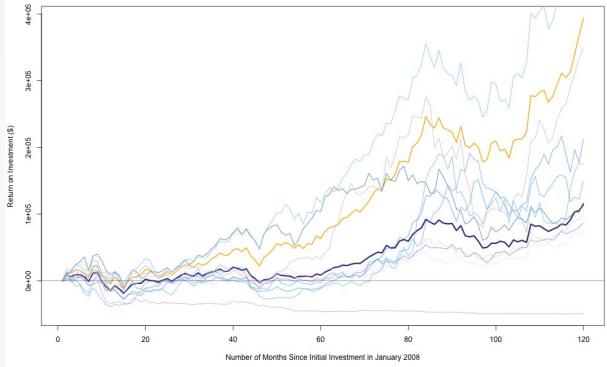
**Sit-And-Wait**

# Transportation

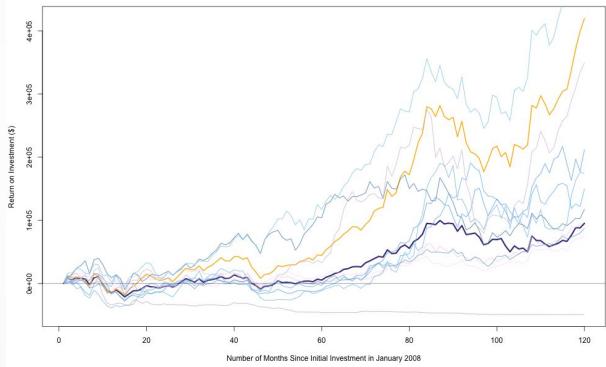
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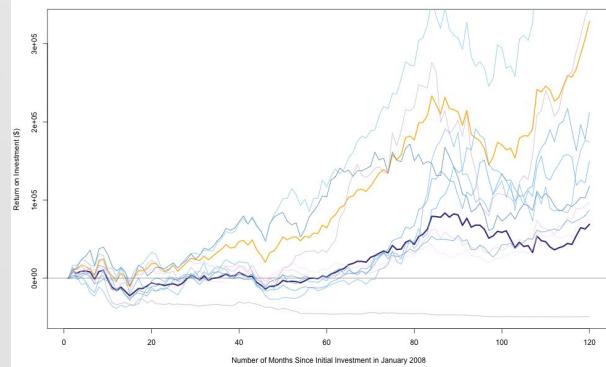
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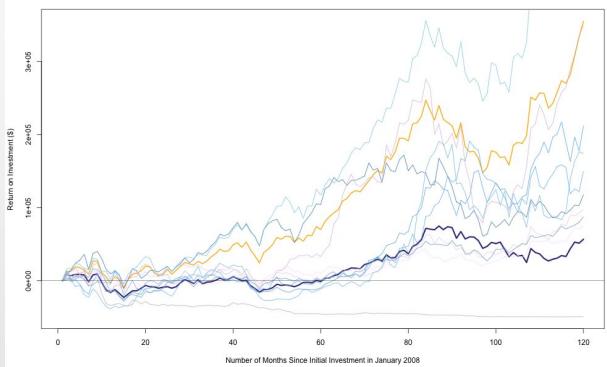
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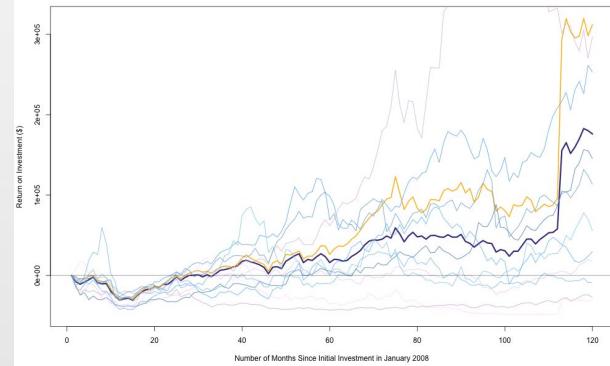
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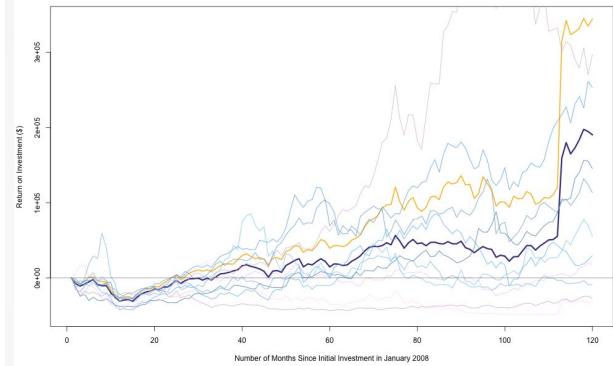
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# Technology

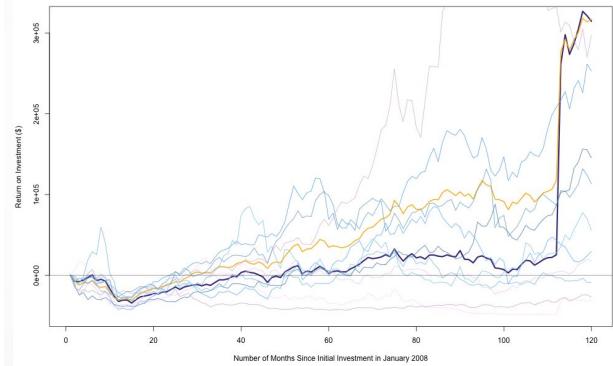
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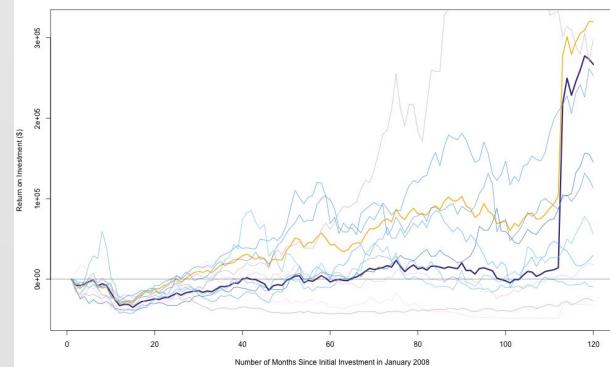
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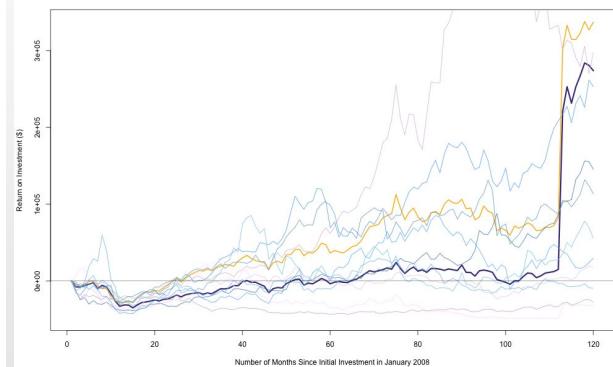
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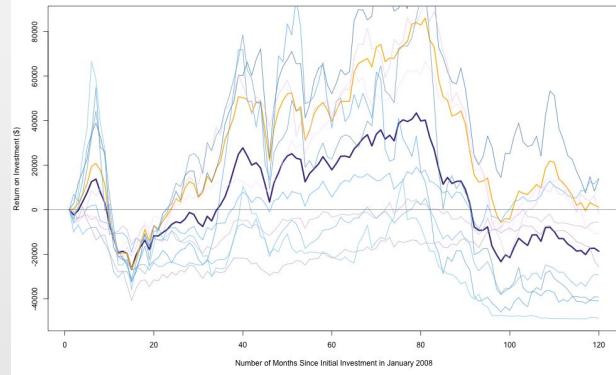
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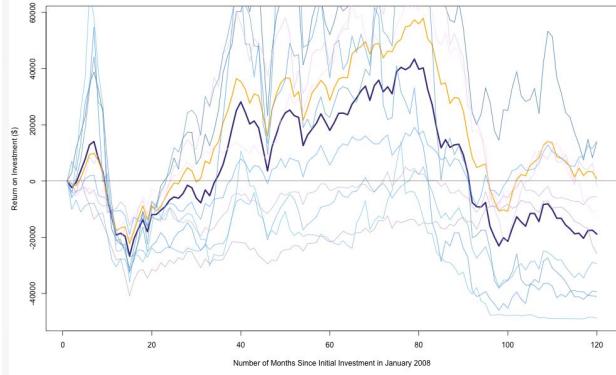
**Sit-And-Wait**

# Energy

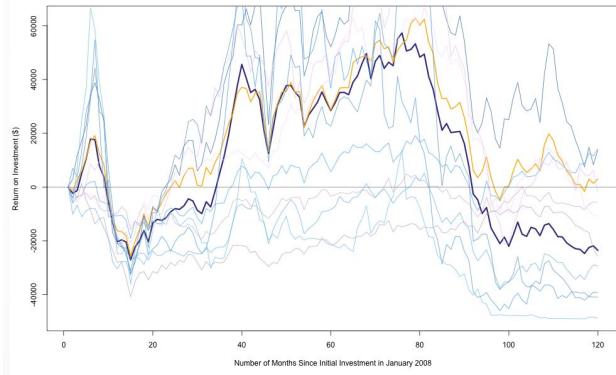
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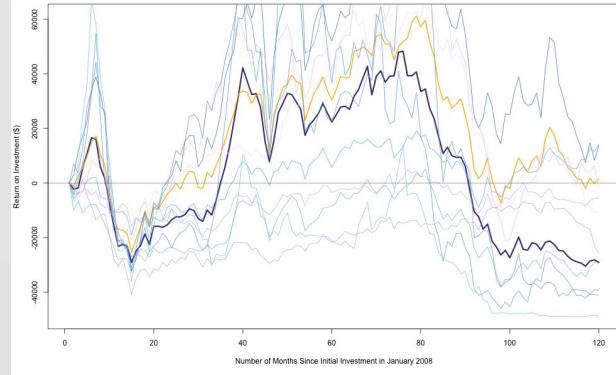
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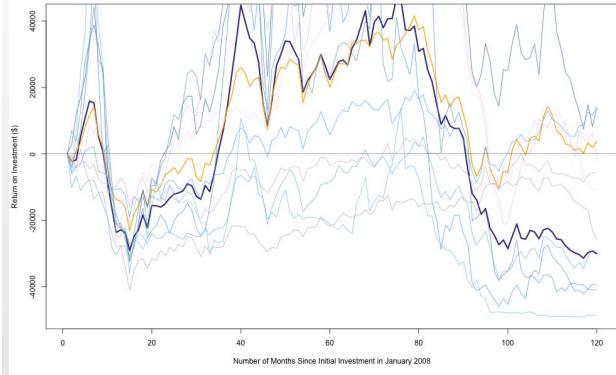
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**Key**

**BCRP**

**EG**

**Sit-And-Wait**

# 95% Bootstrap Confidence Intervals For Return on \$10,000 investment using EG Algorithm (\$0)



# Potential Sources of Bias & Error

- Survival Bias in selecting retrospective cohort
- The randomly chosen companies may not be representative of the sector's distribution
- 10 year window encompasses multiple business cycles
- Investments begin at the dawn of a major economic recession



# Conclusions

- Broker fees can eliminate profit margins based on the level of investment
  - As the investment level grows, the broker fees become less significant
    - I.e. as amount initially invested increased (\$100,000)
    - => ROI w/ broker fees eventually  $\approx$  ROI w/o broker fees.
- EG algorithm consistently outperformed individual stocks at higher investment levels
- The varying optimum eta values is supported by our prior understandings of the market
  - However we did NOT find these relationships to be statistically significant after bootstrapping our original samples

# Where to go from here/ further research

- How would our results have changed had we chosen a different time frame?
  - Shorter/longer investment period
  - More frequent/less frequent transactions
- Would the algorithm perform better with a more diverse set of companies?
- Perhaps we would have seen better results had we fed the algorithm a higher concentration of stock prices in order more frequently adjust weight vectors, while leaving the number of transaction periods constant.

