FRE-GY 6883 Financial Computing
Course Team Projects

Evaluate the impact of quarterly earnings report on stock price movement

Team Members
Zhiheng Wang
Ken Chen
Jingzhao Zhang
Yiwen Zhuang
Zedi Qiu

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Introduction

- **Research Topic - PEAD anomaly**
  - An earnings surprise occurs when a company's reported quarterly or annual profits are above or below analysts' expectations.
  - The tendency of stock prices to drift (over time) in the direction of earnings surprise post the announcement of earnings is termed as PEAD anomaly.
- **Project description**
  - C++ based console application
  - Fetches data online and calculates statistics
  - Present calculation results with GNU plot

Task Allocation

Name	Task
Zhiheng Wang	Stock data storage design, 4 statistic calculation
Ken Chen	Zack query, Yahoo API query, calendar manager, sanity check, unit test, DB operations
Jingzhao Zhang	Vector/Matrix class, operator overloading, flow chart
Yiwen Zhuang	Bootstrap algorithm, Main engine
Zedi Qiu	GNU plot, Main engine design

Group Selected Stocks (Matlab)

Goals:

- From Zacks, **pull 2020 3rd quarter earnings releases**
- For all Russell 1000 stocks, **sort and divide them into 3 groups**

Details:

$$\text{Surprise\%} = \frac{\text{Reported EPS} - \text{EPS Estimate}}{\text{abs(EPS Estimate)}}$$

- Calculate **earnings surprise** for each stock (Surprise % from Zacks).
- Sort all the surprises in **ascending order**, and split all the stocks into **3 groups** with relatively equivalent numbers of stocks:
  - Highest surprise group: Beat Estimate Group
  - Lowest surprise group: Miss Estimate Group
  - The rest stocks in between: Meet Estimate Group
- Save the results in a **CSV file(s)** for using by your C++ application.

```
function [ earnings ] = scrapeEarningsZacks( Stock )
s=urlread('http://zacks.thestreet.com/CompanyView.php','post',{'ticker',Stock});
try etst=strfind(s,'Surprise%</strong></div></td>');
……
```

```
% sort surprises data in ascending order, get loc(ranking)
surprises = cell2mat(results(:,7));
[~, loc] = sort(surprises);
……
```

```
% split all the stocks into 3 groups
for i = 1:3
  group_start = floor(used_ticker_nums * (i-1) / 3) + 1;
  group_end = floor(used_ticker_nums * i /3);
  disp([group_start, group_end]);
  results_group = sorted_results(group_start:group_end, :);
  if i == 1
     filename = 'Miss';
  elseif i==2
     filename = 'Meet';
  else
     filename = 'Beat';
  end
  writecell(results_group, [filename, '.csv']);
end
……
```

Group Selected Stocks

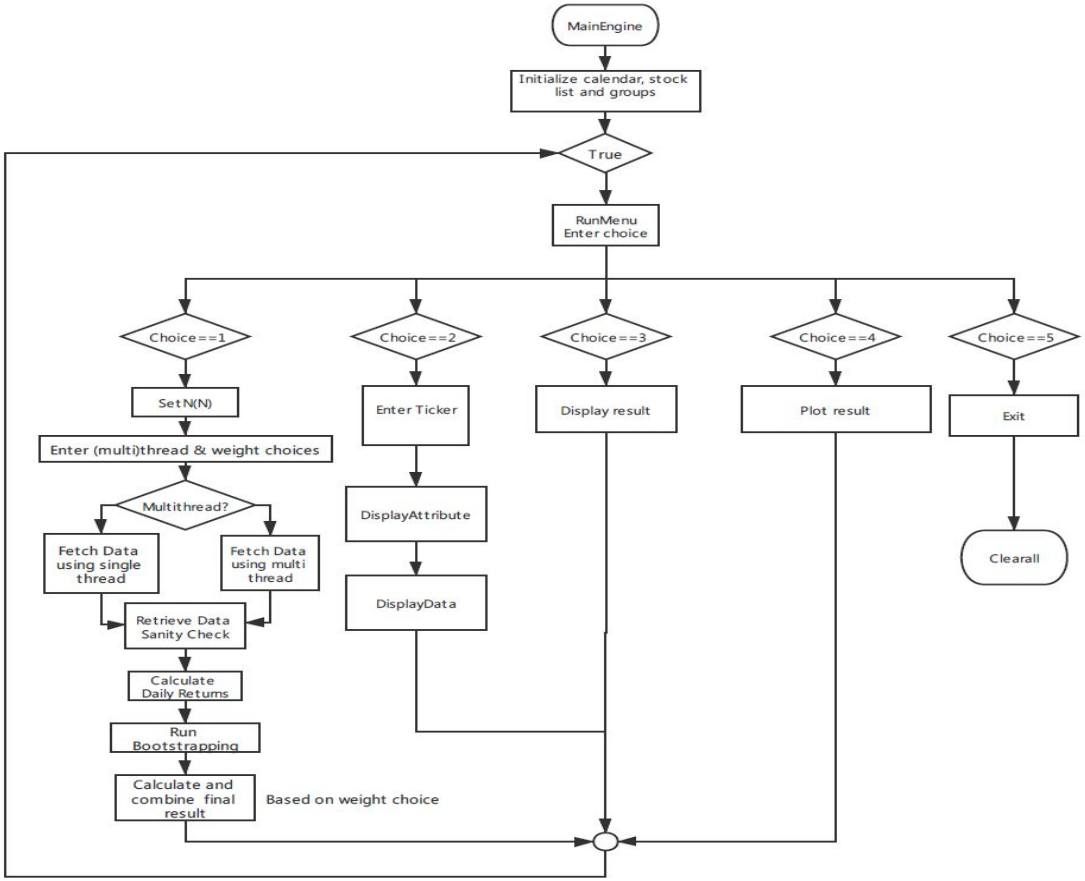
Files

- **GetEPS.m**: main script to query data and split data.
- **scrapeEarningsZacks.m**: lib to query data from Zacks.
- **FilterEPS.m**: filter and split data based on all_surprises.csv.
- **all_surprises.csv**: ungrouped data.
- **Miss.csv**: Miss estimate group data.
- **Meet.csv**: Meat estimate group data.
- **Beat.csv**: Beat estimate group data.
- **Russell_1000_component_stocks.csv**: Russell 1000 stock names.

Data example:

Ticker	Announcement Date	Period Ending	Estimate	Reported	Surprise	Surprise%
AAPL	27-JAN-2021	Oct 2020	1.41	1.68	0.27	19.15
AI	29-OCT-2020	Sep 2020	0.69	0.73	0.04	5.80

Flow Chart


MainEngine
Initialize calendar, stock list and groups
True
RunMenu Enter choice
Choice==1
Choice==2
Choice==3
Choice==4
Choice==5
SetN(N)
Enter (multi)thread & weight choices
Multithread?
Fetch Data using single thread
Fetch Data using multi thread
Retrieve Data Sanity Check
Calculate Daily Returns
Run Bootstrapping
Calculate and combine final result
Based on weight choice
Enter Ticker
DisplayAttribute
DisplayData
Display result
Plot result
Exit
Clearall

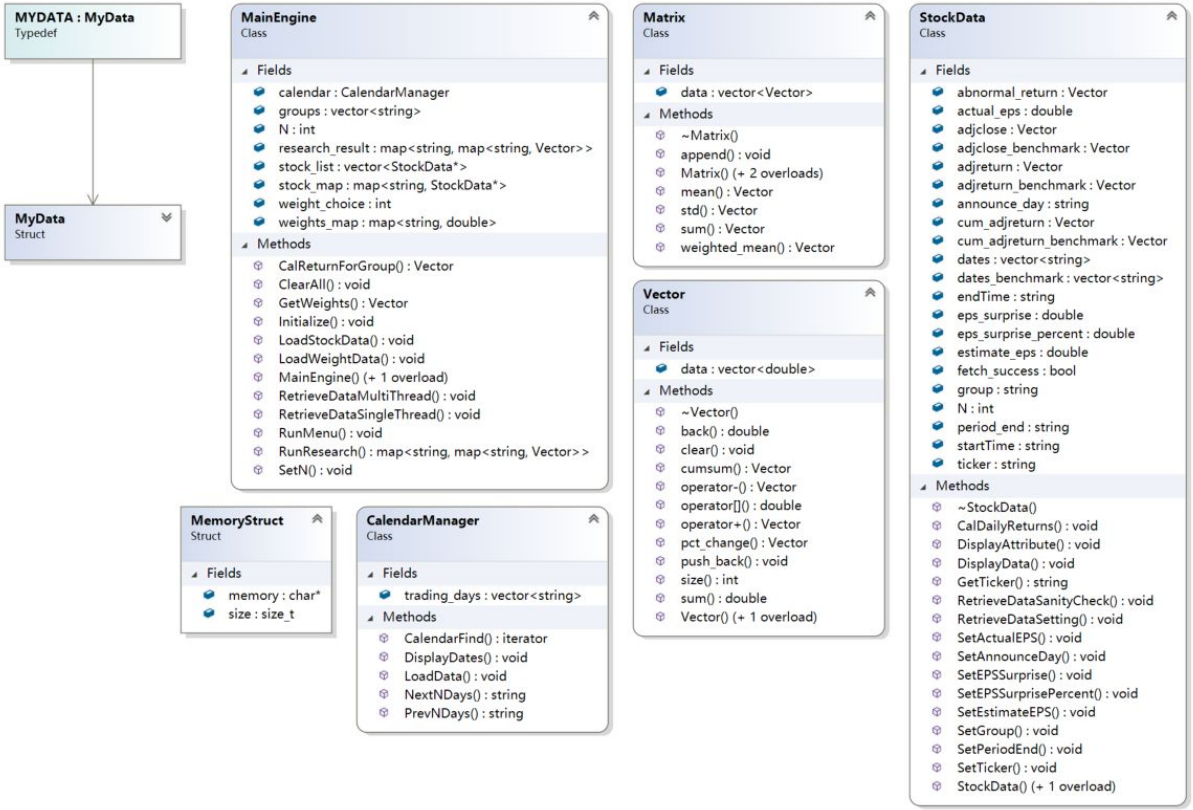
Flow Chart Explanation 1

Create an instance of MainEngine that combines all methods

Initialize()

1	CalendarManager **calendar**	calendar.LoadData()	-get all trading days
2	vector<StockData*> **stock_list**	LoadStockData()	-get stock list for 3 groups from local grouped EPS files -call load_stock_data() from Utils.cpp -initialized a stock_list of type vector<StockData*>
3	map<string, double> **weights_map**	LoadWeightData()	-load IWB weights from local csv file
4	map<string,StockData*> **stock_map**	create_stock_map(stock_list)	-create a stock_map using function in Utils.cpp -ticker with StockData* that contains all info about each stock
5	vector<string> **groups**	push_back("")	-initialize by push back 3 groups' name

UML


MYDATA : MyData
Typedef
MyData
Struct
MainEngine
Class
Fields
calendar : CalendarManager
groups : vector<string>
N : int
research_result : map<string, map<string, Vector>>
stock_list : vector<StockData*>
stock_map : map<string, StockData*>
weight_choice : int
weights_map : map<string, double>
Methods
CalReturnForGroup() : Vector
ClearAll() : void
GetWeights() : Vector
Initialize() : void
LoadStockData() : void
LoadWeightData() : void
MainEngine() (+ 1 overload)
RetrieveDataMultiThread() : void
RetrieveDataSingleThread() : void
RunMenu() : void
RunResearch() : map<string, map<string, Vector>>
SetN() : void
Matrix
Class
Fields
data : vector<Vector>
Methods
~Matrix()
append() : void
Matrix() (+ 2 overloads)
mean() : Vector
std() : Vector
sum() : Vector
weighted_mean() : Vector
StockData
Class
Fields
abnormal_return : Vector
actual_eps : double
adjclose : Vector
adjclose_benchmark : Vector
adjreturn : Vector
adjreturn_benchmark : Vector
announce_day : string
cum_adjreturn : Vector
cum_adjreturn_benchmark : Vector
dates : vector<string>
dates_benchmark : vector<string>
endTime : string
eps_surprise : double
eps_surprise_percent : double
estimate_eps : double
fetch_success : bool
group : string
N : int
period_end : string
startTime : string
ticker : string
Methods
~StockData()
CalDailyReturns() : void
DisplayAttribute() : void
DisplayData() : void
GetTicker() : string
RetrieveDataSanityCheck() : void
RetrieveDataSetting() : void
SetActualEPS() : void
SetAnnounceDay() : void
SetEPSSurprise() : void
SetEPSSurprisePercent() : void
SetEstimateEPS() : void
SetGroup() : void
SetPeriodEnd() : void
SetTicker() : void
StockData() (+ 1 overload)
Vector
Class
Fields
data : vector<double>
Methods
~Vector()
back() : double
clear() : void
cumsum() : Vector
operator-() : Vector
operator[]() : double
operator+() : Vector
pct_change() : Vector
push_back() : void
size() : int
sum() : double
Vector() (+ 1 overload)
MemoryStruct
Struct
Fields
memory : char*
size : size_t
CalendarManager
Class
Fields
trading_days : vector<string>
Methods
CalendarFind() : iterator
DisplayDates() : void
LoadData() : void
NextNDays() : string
PrevNDays() : string

Explanations: Vector class

- **Function**

Store vector<double> type of data
Methods to perform calculations

Vector	
+data: vector<double>	
+push_back(const double &val)	push_back new value
+clear()	clear all values in the vector
+size()	get the size of the vector
+back()	get the last element of the vector
+pct_change()	calculate % change by row
+sum()	calculate sum of all elements
+cumsum()	calculate the cumulative sum
+operator-	take the difference of two Vectors
+operator[]	access value in Vector by index
+operator+	add two Vectors together
+operator<<	overload cout

Explanations: Matrix class

- **Function**

Store vector<Vector> type of data
Methods to perform calculations for AAR, AAR-STD, CAAR, CAAR-STD

Matrix
+data: vector<Vector>
+append()
+mean()
+std()
+sum()
+weighted_mean()
+operator<<

append row at the end
calculate mean by column
calculate std by column
calculate sum by column
calculate weighted mean by column
overload cout

Explanation: CalendarManager class

- **Function**

Locate the all the trading dates and earning announcement date and display the trading dates before and after the earnings announcement date

CalendarManager	
- trading_days: vector<string>	All trading days from 1/3/2011 to 4/27/2021.
+ LoadData()	Load trading days from local file.
+ CalendarFind()	Find the location of a date in a vector.
+ NextNDays()	Find the N-th trading day after day0.
+ PrevNDays()	Find the N-th trading day before day0.
+ DisplayDates()	Display trading_days.

StockData class

- Calculate and display the information for each single stock in the index.
  .

- **Function**

Calculate and display the information for each single stock in the index

StockData	
- ticker	
- group	
- announce_day	
- period_end	
- estimate_eps	
...	
- startTime	
- endTime	
- N	Input N.
- fetch_success	If download data success, fetch_success=true.
- dates	
- adjclose	
- adjreturn	
- adjclose_benchmark	
...	
- abnormal_return	
...	
+ RetrieveDataSetting()	Set startTime, endTime. Clear previous data.
+ RetrieveDataSanityCheck()	After fetching data, sanity check if data is valid.
+ CalDailyReturns()	Calculate return and abnormal return.
+ DisplayAttribute()	Display attribution information of the stock.
+ DisplayData()	Display price/return data of the stock.

Explanations: MainEngine class

- **Function:** pull the information for each individual stock, conduct research and display the results. Clients can access the stock data and plot the results using manu.

MainEngine	
-Stock_list	Store the stocks and corresponding price information for each group in a STL map
-ticker	Stock symbol
-weight	Stock Market Cap weights according to the bechmark
-AAR	Abnromal return for each stock
-CAAR	Cumuated Abnormal Return for first T days
-AARt	Daily abnormal returns for each group of stocks
-AAR_mean	Mean of AARt from bootstrap Algorithm
-CAAR_mean	Mean of AARt from bootstrap Algorithm
-AAR_std	Standard Deviation of AARt from bootstrap Algorithm
-CAAR_std	Standard Deviation of CAAR from bootrap Algorithm
-% Earnings Surprise	(Reported EPS- EPS Estimate)/abs(EPS Estimate)
+ Initialize()	Initialize stock list and the group information
+ LoadStockData()	Load and combine the stock list
+ LoadWeightData()	Load the stock market cap weights according to the benchmark
+ RetrieveDataSingleTread()	Retrieve all the stock data and display return information with single thread
+ RetrieveDataMultiTread()	Retrieve all the stock data and display return information with multiple thread
+ RunResearch()	Run bootrap algorithm and calculate the mean and standard deviation of Abnormal returns and the cumulative standard abnormal returns
+ CalReturnForGroup()	Calculate the abnormal return for each group of stock
+ GetWeights()	Get the weights information for each group of stock
+ RunMenu()	Run the Manu which can search the information for individual stock, and AAR, AAR-SD, CAAR, and CAAR_STD for one group
+ ClearAll()	Delete all the preivously initialized pointers

Explanations: Bootstrap algorithm

```
map<string, vector<StockData*>> bootstrapping(vector<StockData*> stock_list, int seed)
{
        int bootstrap_num = BOOTSTRAP_NUM;
        default_random_engine random(time(NULL) + seed);
        std::uniform_real_distribution<double> dist(0.0, 1.0);

        vector< pair<StockData*, double> > vec;
        for (int i = 0; i < stock_list.size(); i++)
        {
                vec.push_back(pair<StockData*, double>(stock_list[i], dist(random)));
        }

        sort(vec.begin(), vec.end(), cmp);
```

Shuffle stocks by giving random number to each stock and sort by the value.

Select 50 stocks for each groups (eg. “Beat Group”)

```
vector<StockData*> beat_result;
for (auto iter : vec)
{
        if ((iter.first->group == "Beat") && (iter.first->fetch_success))
        {
                beat_result.push_back(iter.first);
                if (beat_result.size() == bootstrap_num) break;
        }
}
```

```
map<string, vector<StockData*>> bootstrap_result;
bootstrap_result["Beat"] = beat_result;
bootstrap_result["Meet"] = meet_result;
bootstrap_result["Miss"] = miss_result;

return bootstrap_result;
```

Store data in a map for further calculation and plotting

Explanations: Bootstrap algorithm

```
map<string, map<string, Vector>> MainEngine::RunResearch()
```

```
map<string, vector<Vector>> AAR;
map<string, vector<Vector>> CAAR;
map<string, map<string, Vector>> result;
```

Map initialization

```
for (int i = 0; i < RUN_BOOTSTRAP_NUM; i++)
{
    map<string, vector<StockData*>> bootstrap_result = bootstrapping(stock_list, i);
    for (auto iter : groups)
    {
        AAR[iter].push_back(CalReturnForGroup(bootstrap_result[iter]));
        CAAR[iter].push_back(AAR[iter].back().cumsum());
    }
```

Bootstrap 40 times; get AAR CAAR for each time.

Get average and standard deviation for AAR, CAAR for each group

```
for (auto iter : groups)
{
    Matrix AAR_mean(AAR[iter]);
    Matrix CAAR_mean(CAAR[iter]);
    //AAR_mean.display(); // check if random see valid
    result["AAR_mean"][iter] = Matrix(AAR[iter]).mean();
    result["CAAR_mean"][iter] = Matrix(CAAR[iter]).mean();
    result["AAR_std"][iter] = Matrix(AAR[iter]).std();
    result["CAAR_std"][iter] = Matrix(CAAR[iter]).std();
}
research_result = result;
return result;
```

Final Result

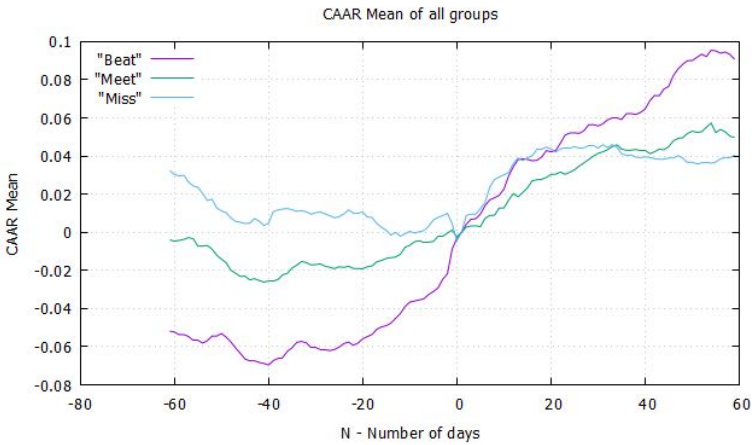
Equal Weights

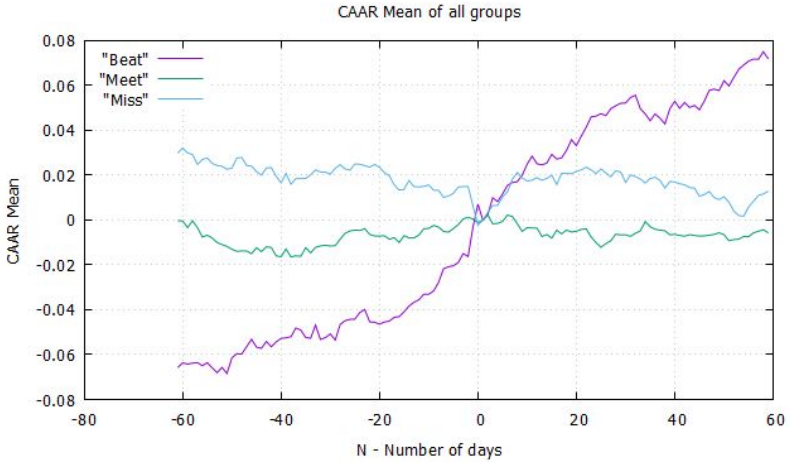
$$AAR_t = \frac{1}{M}\sum_{i=1}^{M} AR_{it}$$

Market Cap Weights

$$AAR_t = \frac{1}{\sum_{i=1}^{M} w_i}\sum_{i=1}^{M} AR_{it} * w_i$$

$$\mathrm{CAAR} = \sum_{t=-N}^{T} \mathrm{ARRt},\ \mathrm{T} = \mathrm{N}$$





Research Conclusion

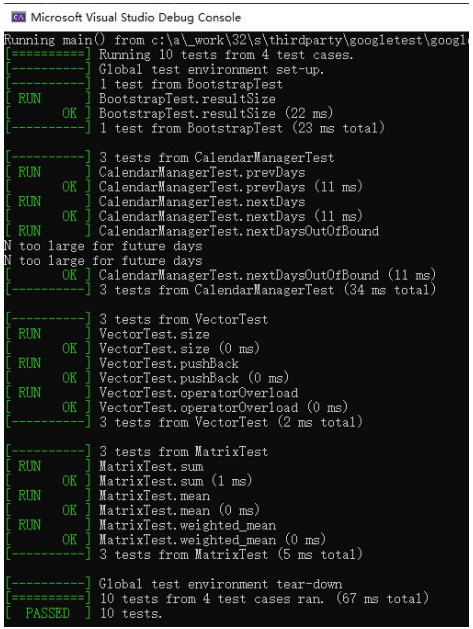
- Before announcement day, stocks in Beat group show positive abnormal return while stocks in Miss group show negative abnormal return. This might because investors are reacting to the information in the markets before earnings announcement and market gradually prices in the earnings surprise.

- After announcement day, stocks in Beat group show more positive abnormal returns than other groups. The effect lasts for 60 days which probably implies that investors react slowly to the earnings surprise information. Stocks in Meet/Miss group shows no significant abnormal returns.

Enhancement

- **Unit test – Google Test**

Test-Driven development.



- **Fetch data with multi-threading**

Producer-consumers model.
Create thread pool.
Time consumption decreases from 660s to 88s with a pool of 10 threads.

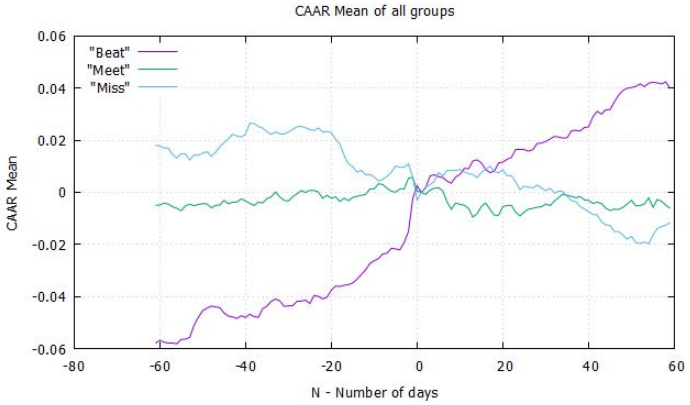
```
void thread_producer(tasks){
  for(task in tasks)
        mutex.lock();
        queue.push_front(task);
        mutex.unlock();
        cond_variable.notify_all();
  mutex.lock();
  queue.push_front(poison_pill);
  mutex.unlock();
  cond_variable.notify_all();
}
```

```
void thread_consumer(){
   while(1){
     while (queue.empty())
       cond_variable.wait(mutex);
     if(queue.back()==poison_pill)
       terminate thread;
     else:
       mutex.lock();
       task = pop_back();
       mutex.unlock();
     run task;}
}
```

Enrichment

- **EQAL as benchmark**

We calculate AARt by equal weights.
It makes sense to use equal weighted Russell 1000 ETF as benchmark.
However EQAL is not as liquid as IWB.



- **Manage local data with SQLite3 DB**

Data loading time decreases from 660s to 13s.
Robust to Internet/Yahoo API conditions.

StockInfo table

	Ticker	EPS_Estim	EPS_Actua	EPS_Surpr	EPS_Surpr	Stock_Gro	Announce_Da	Period_En
1	NOV	0.1	-0.61	-0.71	-710	Miss	2019-10-28	Sep 2019
2	PEGA	-0.06	-0.23	-0.17	-283.3	Miss	2019-11-07	Sep 2019
3	SBAC	2.08	0.19	-1.89	-90.8	Miss	2019-10-28	Sep 2019
4	INVH	0.31	0.06	-0.25	-80.6	Miss	2019-10-29	Sep 2019
5	WYNN	0.88	0.17	-0.71	-80.6	Miss	2019-11-06	Sep 2019
6	VST	0.94	0.25	-0.69	-73.4	Miss	2019-11-05	Sep 2019
7	OXY	0.41	0.11	-0.3	-73.1	Miss	2019-11-04	Sep 2019
8	FSLR	1.06	0.29	-0.77	-72.6	Miss	2019-10-24	Sep 2019
9	MOS	0.27	0.08	-0.19	-70.3	Miss	2019-11-04	Sep 2019
10	LBRDK	0.44	0.15	-0.29	-65.9	Miss	2019-11-01	Sep 2019
11	NXST	1.52	0.61	-0.91	-59.8	Miss	2019-11-06	Sep 2019
12	NLOK	0.42	0.18	-0.24	-57.1	Miss	2019-11-07	Sep 2019
13	TRGP	-0.22	-0.34	-0.12	-54.5	Miss	2019-11-07	Sep 2019
14	RNR	0.63	0.29	-0.34	-53.9	Miss	2019-10-29	Sep 2019
15	SGEN	-0.37	-0.54	-0.17	-45.9	Miss	2019-10-29	Sep 2019
16	CVNA	-0.39	-0.56	-0.17	-43.5	Miss	2019-11-06	Sep 2019
17	AIG	0.99	0.56	-0.43	-43.4	Miss	2019-11-01	Sep 2019
18	TRV	2.38	1.43	-0.95	-39.9	Miss	2019-10-22	Sep 2019
19	TDS	0.23	0.15	-0.08	-34.7	Miss	2019-10-31	Sep 2019
20	BA	2.04	1.45	-0.59	-28.9	Miss	2019-10-23	Sep 2019
21	USM	0.38	0.27	-0.11	-28.9	Miss	2019-10-31	Sep 2019
22	SRPT	-1.34	-1.7	-0.36	-26.8	Miss	2019-11-07	Sep 2019
23	ATH	1.8	1.34	-0.46	-25.5	Miss	2019-11-05	Sep 2019
24	MCY	1	0.78	-0.22	-22	Miss	2019-10-28	Sep 2019
25	AGR	0.51	0.4	-0.11	-21.5	Miss	2019-10-29	Sep 2019
26	ASH	0.98	0.77	-0.21	-21.4	Miss	2019-11-18	Sep 2019
27	TDC	0.4	0.32	-0.08	-20	Miss	2019-11-07	Sep 2019

MarketData table

	Ticker	Date	Adj_Close
1	NOV	2019-09-16	23.227243
2	NOV	2019-09-17	22.492393
3	NOV	2019-09-18	22.780378
4	NOV	2019-09-19	22.730722
5	NOV	2019-09-20	22.403021
6	NOV	2019-09-23	22.532118
7	NOV	2019-09-24	21.409979
8	NOV	2019-09-25	22.124969
9	NOV	2019-09-26	21.91643
10	NOV	2019-09-27	21.886641
11	NOV	2019-09-30	21.052485
12	NOV	2019-10-01	20.714849
13	NOV	2019-10-02	20.327562
14	NOV	2019-10-03	20.774431
15	NOV	2019-10-04	20.893599
16	NOV	2019-10-07	20.546032
17	NOV	2019-10-08	20.138887
18	NOV	2019-10-09	20.049511
19	NOV	2019-10-10	20.536102

Reference

- PEAD anomaly (https://en.wikipedia.org/wiki/Post%E2%80%93earnings-announcement_drift)

- US trading calendar (https://tushare.pro/document/2?doc_id=253)

- C++ Concurrency in Action by Anthony Williams (https://www.cplusplusconcurrencyinaction.com/)

- Google Test (https://github.com/google/googletest)

- IWB Holdings Weights (https://www.ishares.com/us/products/239707/ishares-russell-1000-etf)

- SQLite for C++ (https://www.tutorialspoint.com/sqlite/sqlite_c_cpp.htm)

Thank you