

# Real Estate Portfolio Optimization

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# **1. Previous Literature**

1. IBMQ Portfolio Optimization
2. Why Real Estate Portfolio

# **2. REPO**

1. How REPO works
2. LSTM
3. QA

# **3. Result**

# **4. Conclusion**

# 1. PREVIOUS RESEARCH

# 1) IBMQ Portfolio Optimization

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QUBO

Quadratic Unconstrained  
Binary Optimization

$$\min f(x) = \min_{x \in \{0,1\}^n} x^T Q x + q^T x$$



IBMQ Portfolio  
Optimization

stock & bond  
Portfolio Optimization

$$\min_{x \in \{0,1\}^n} q x^T \Sigma x - \mu^T x$$

subject to :  $1^T x = B$

## 2) Why Real Estate Portfolio

best portfolio optimization method that can be expressed as 0 and 1

IBMQ Portfolio  
Optimization



Real Estate Portfolio  
Optimization

$$\min_{x \in \{0,1\}^n} q x^T \Sigma x - \mu^T x$$

subject to :  $1^T x = B$

$$\min_{x \in \{0,1\}^n} q x^T \Sigma x - \mu^T x + c^T x$$

problem

① only binary options  
allowed to buy an asset

okay

problem

② no budget constraint

okay

problem

③ can only buy  
fixed number of assets

removed

## 2) Why Real Estate Portfolio

### IBMQ Portfolio Optimization

$$\begin{aligned} \min_{x \in \{0,1\}^n} & \quad qx^T \Sigma x - \mu^T x \\ \text{subject to : } & \quad 1^T x = B \end{aligned}$$

- Pick or not
  - $x \in \{0,1\}^n$  : binary decision variables
- Expected returns
  - $\mu \in \mathbb{R}^n$ : Expected Return of past months
- Covariance
  - $\Sigma \in \mathbb{R}^{n \times n}$  : covariances between the assets
- Risk appetite
  - $q > 0$  : risk appetites of the decision maker (how much risk the investor can bear)
- Budget (num of assets selected)
  - $B$  : number of assets to be selected out of  $n$  assets

## 2) Why Real Estate Portfolio

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IBMQ Portfolio  
Optimization

$$\begin{aligned} \min_{x \in \{0,1\}^n} & \quad qx^T \Sigma x - \mu^T x \\ \text{subject to : } & \quad 1^T x = B \end{aligned}$$

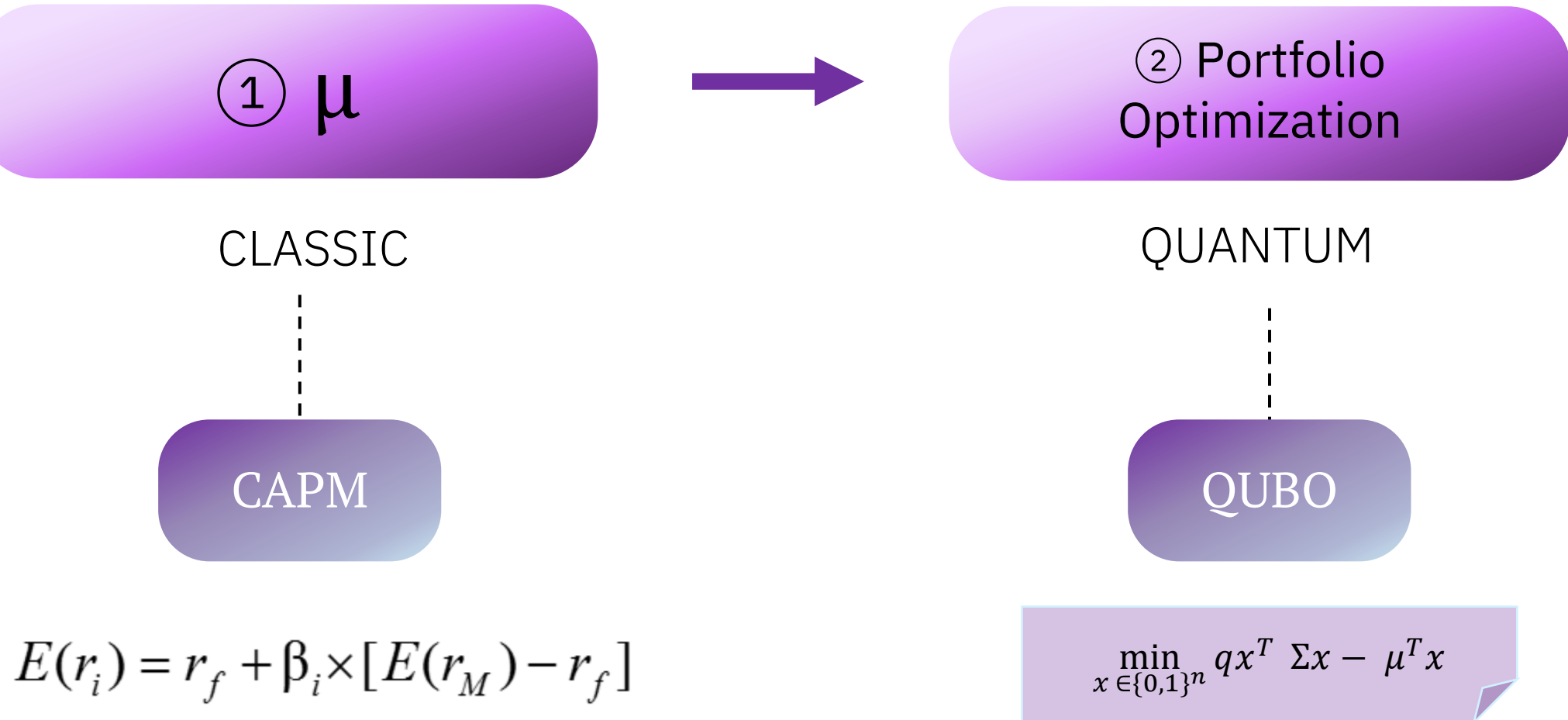
- Expected returns
  - $\mu \in \mathbb{R}^n$  : Expected Return of past months

## 2. REPO



# 1) How REPO Works

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# 1) How REPO Works

①  $\mu$

CLASSIC

CAPM

**R – squared ↓**

univariate CAPM

$$\textcircled{1} \quad E(r_i) = r_f + \beta_i \times [E(r_M) - r_f]$$

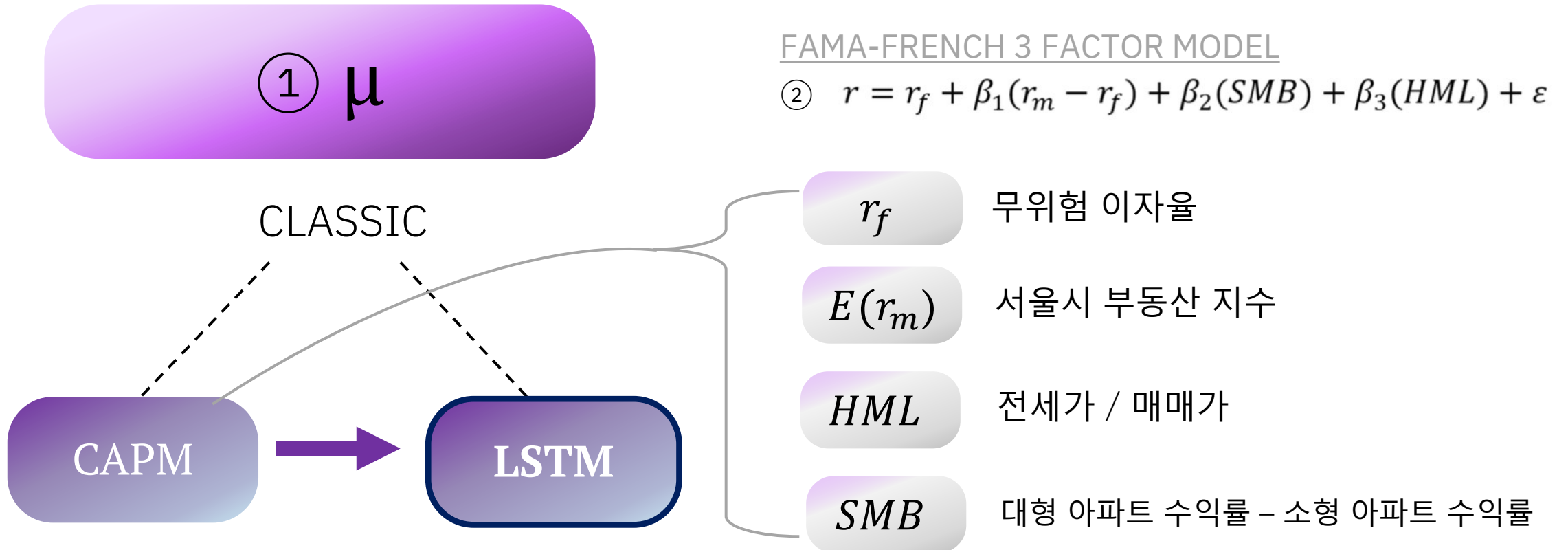
multivariate CAPM

$$\textcircled{2} \quad r = r_f + \beta_1(r_m - r_f) + \beta_2(SMB) + \beta_3(HML) + \varepsilon$$

$$\textcircled{3} \quad r_i - r_f = \alpha_i + \beta_{i,m}(r_m - r_f) + \beta_{i,SMB}SMB + \beta_{i,HML}HML + \beta_{i,MOM}MOM + \varepsilon_i$$

$$\textcircled{4} \quad R_{i,t} - R_{f,t} = \alpha_{i,t} + \beta_{i,t}(R_{m,t} - R_{f,t}) + \sigma SMB_{i,t} + rMom_{i,t} + \delta S^2_{i,t} + e_{i,t}$$

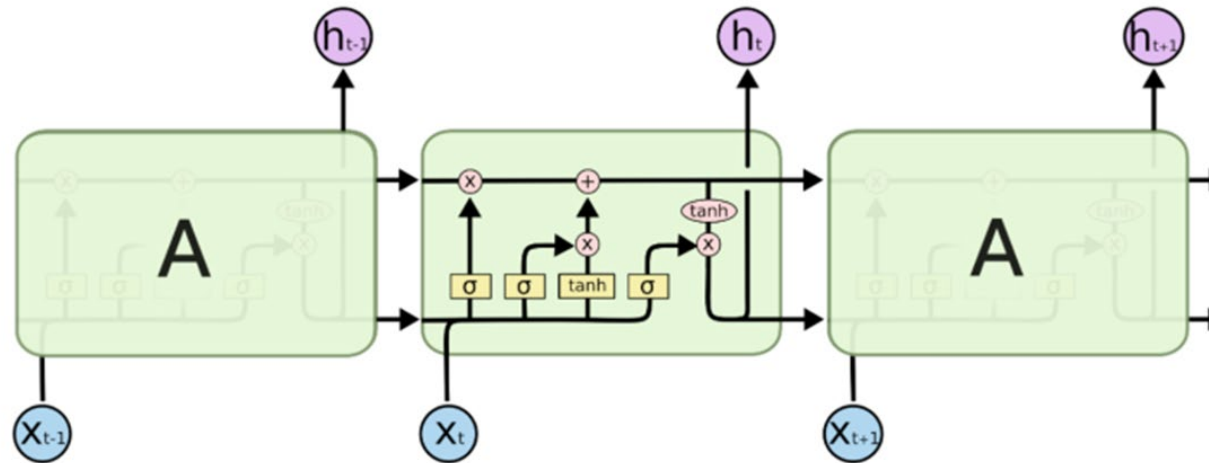
# 1) How REPO Works



## 2) Predict $\mu$ ( LSTM )

### LSTM

- A type of NN designed for handling sequential data
- able to capture long-term dependencies in sequence data



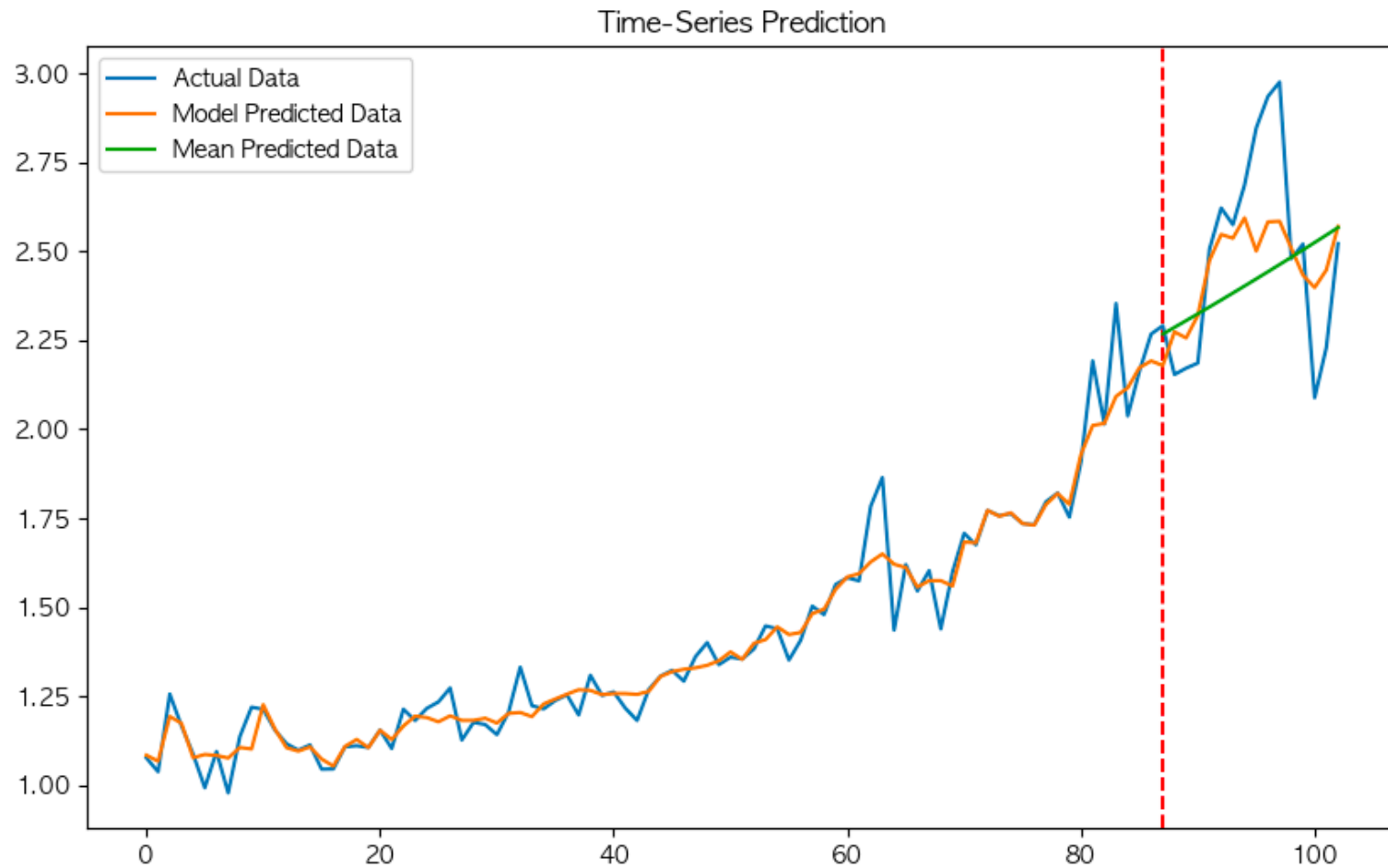
## 2) Predict $\mu$ ( LSTM )

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### Input

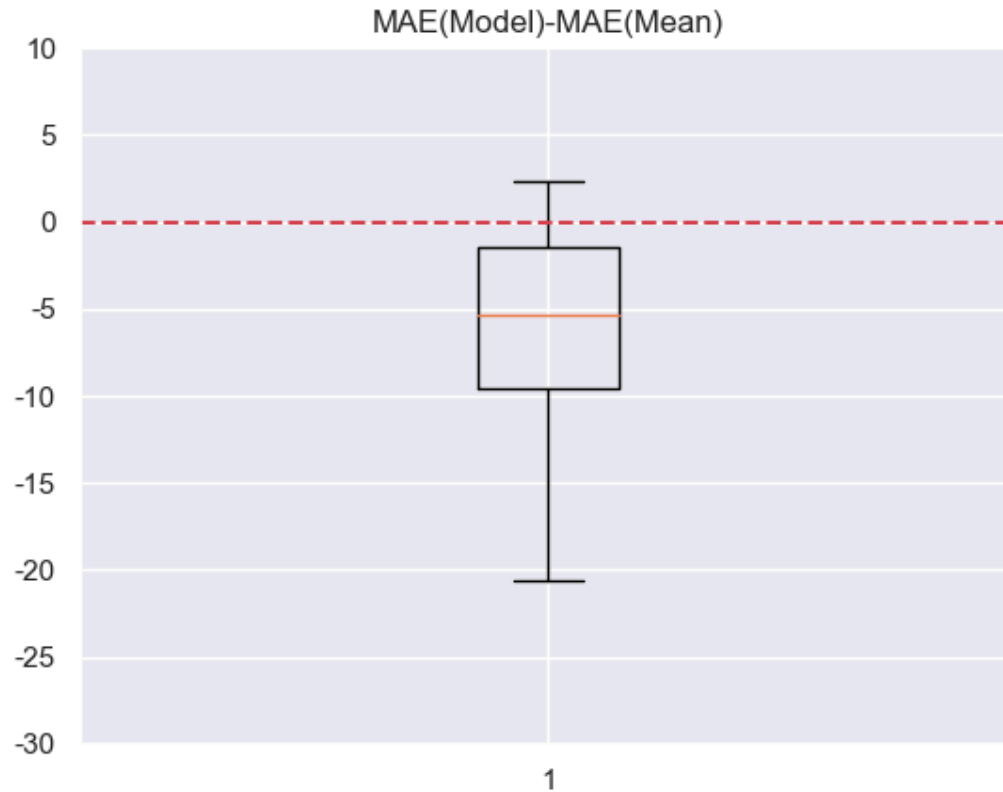
- $Y$  : 서울시 동별 아파트 평균 매매가격 변화율
- $R_m$  : 서울시 부동산 매매지수 변화율
- $R_f$  : 무위험 수익률
- $SMB$ (Small Minus Big) : 대형 아파트 수익률 - 소형 아파트 수익률
- $HML$ (High Minus Low) : 전세가 / 매매가

## 2) Predict $\mu$ ( LSTM )



신내동의 집값 예측 결과

## 2) Predict $\mu$ ( LSTM )



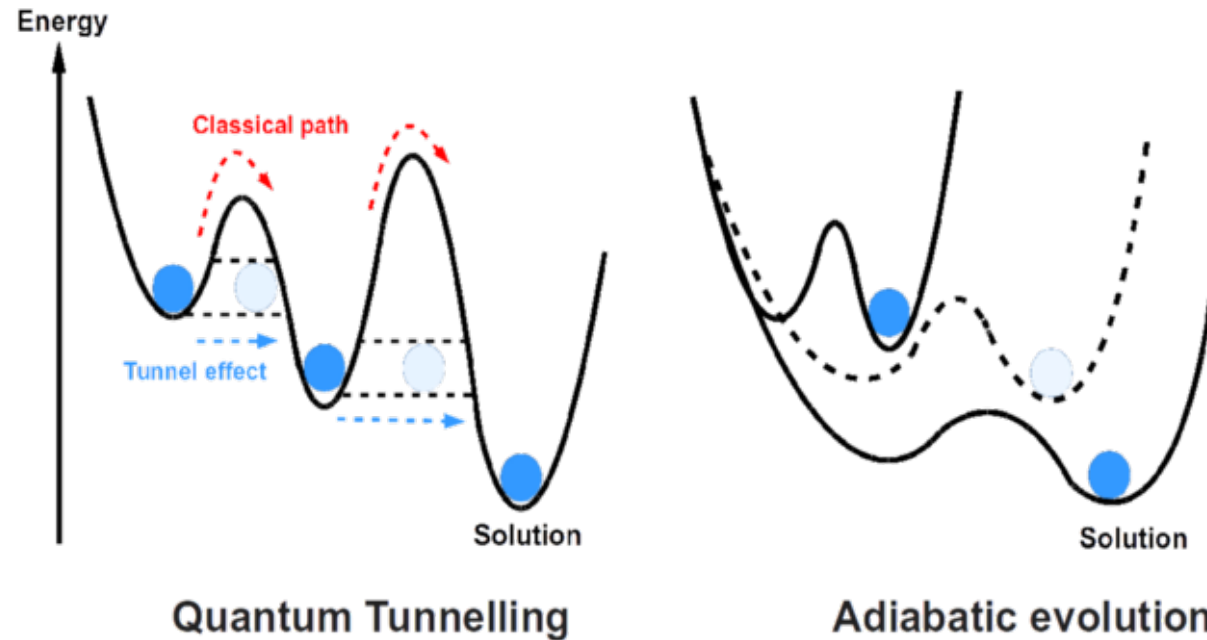
평균 예측 집값과 모델 예측 집값의 Mean  
Absolute Error(MAE)의 차이



총 **113개** 동 중 **96개**의 동에서 개선된  
MAE를 보임

## 2) Quantum Annealing

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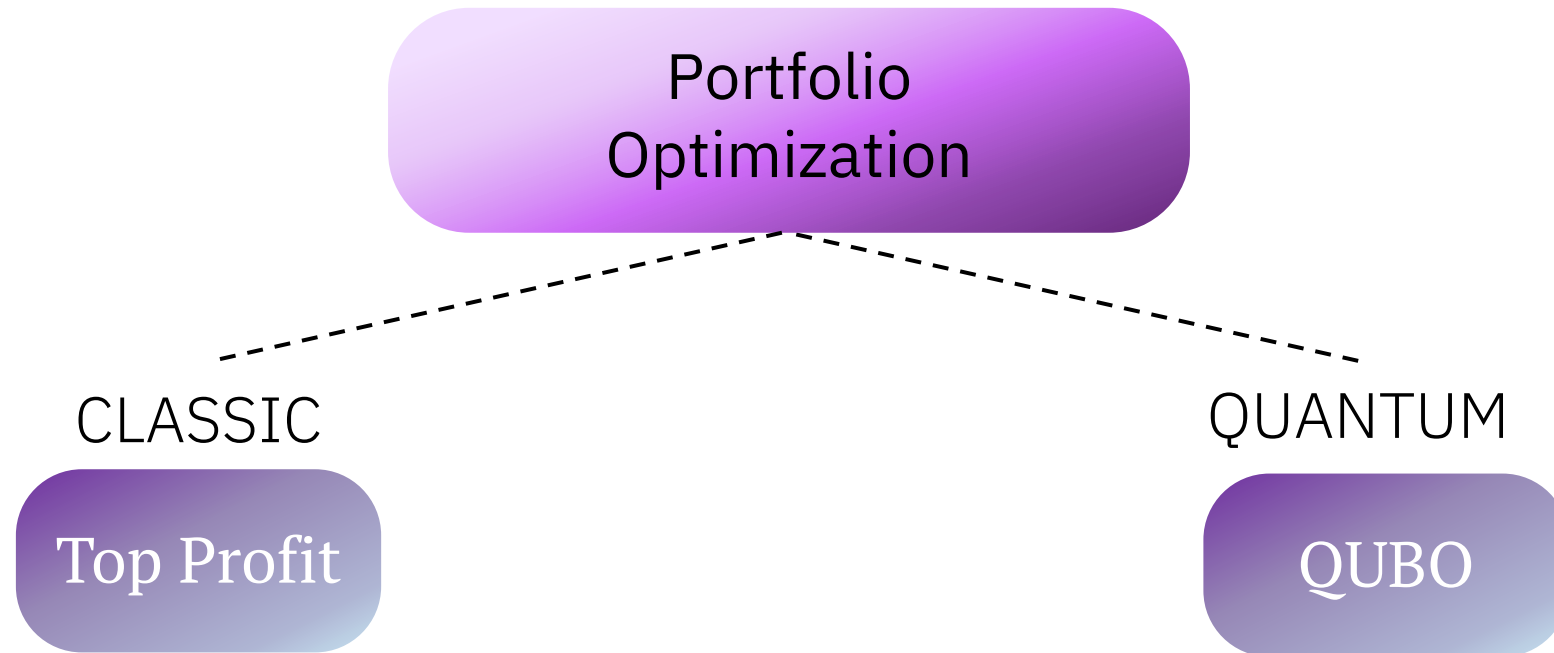
- Optimization process for finding global minimum
- $H(t) = (1 - f(t))H_I + f(t)H_f$



## 3. RESULT

# 1) Experiment1

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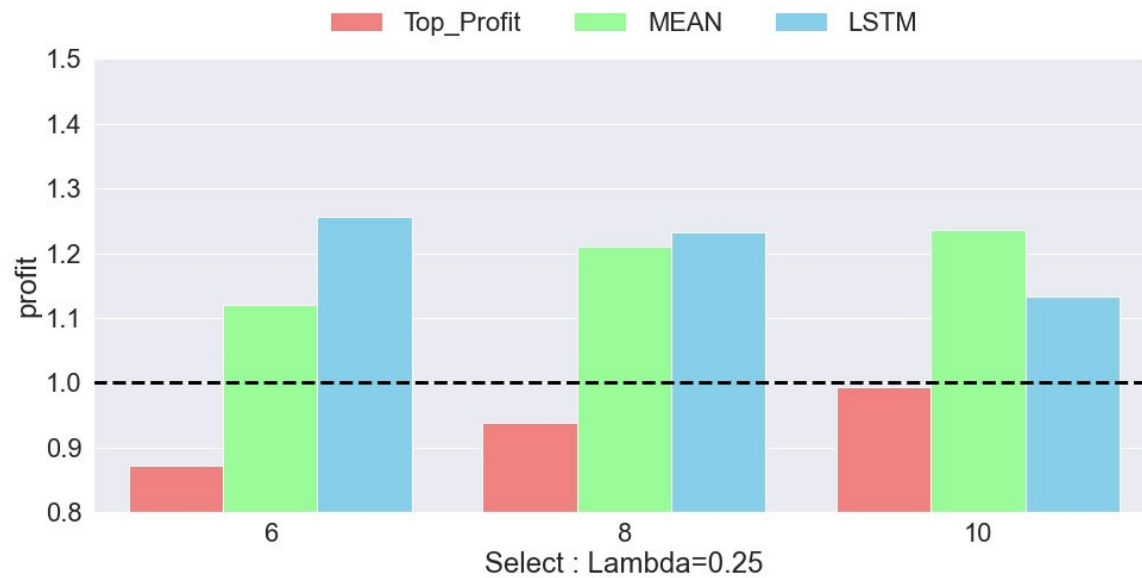


관측 시점에서 수익률 높은 부동산 투자

MEAN : 평균 수익률을  $\mu$ 로 사용한 QUBO

LSTM : LSTM으로 예측한  $\mu$  사용한 QUBO

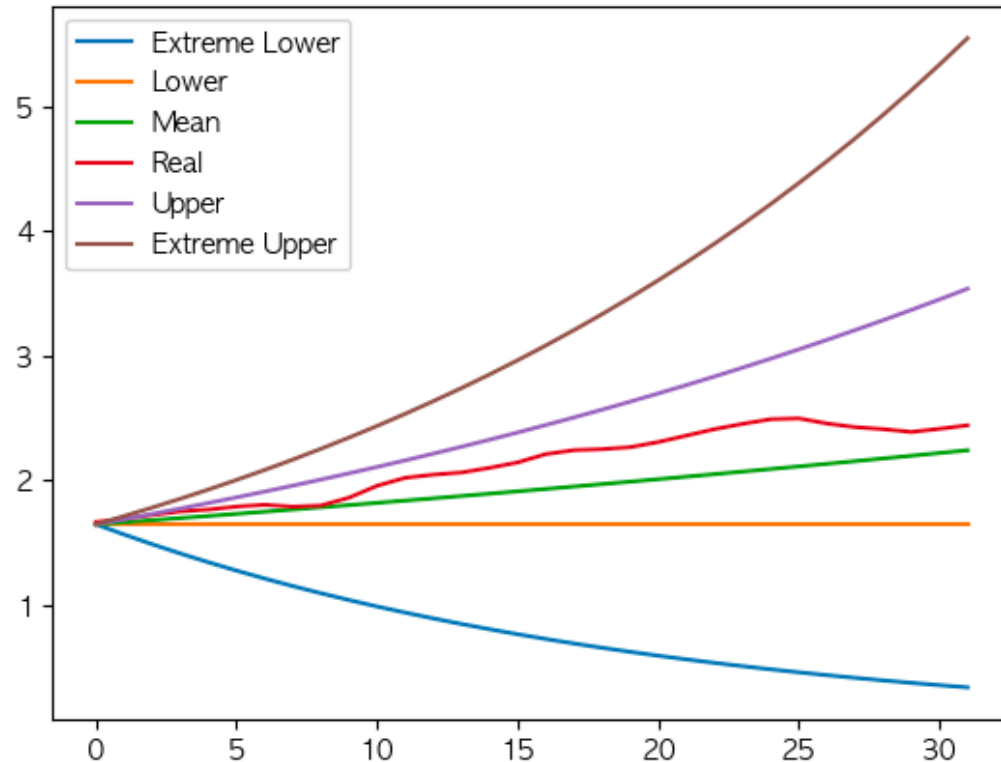
# 1) Experiment1



3가지 방법으로 구성한 포트폴리오의 미래 변동률

Top profit 방법보다 QUBO를 이용한 방법이  
리스크 헷징에 더 좋은 성능을 보여주고 있다!

## 2) Experiment2

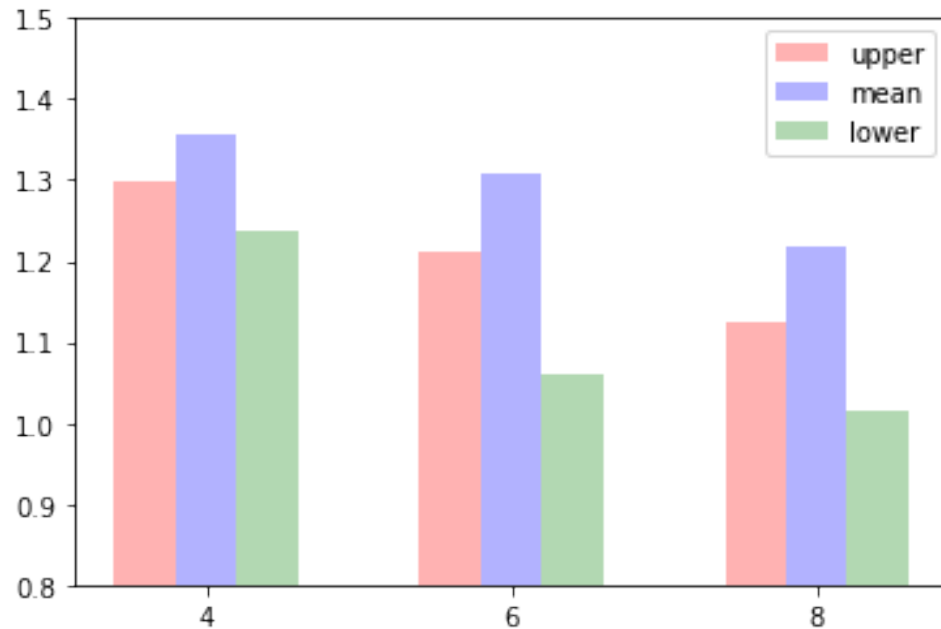


서울시 부동산 매매지수(Systematic Risk)의 전망 예상

**Q.** 시장의 체계적 위험을  
사용자가 예측하여 모델에 넣었을 시  
그에 따른 합리적인 포트폴리오  
제시가 가능할까?

## 2) Experiment2

세가지 전망에 따른 포트폴리오 수익률



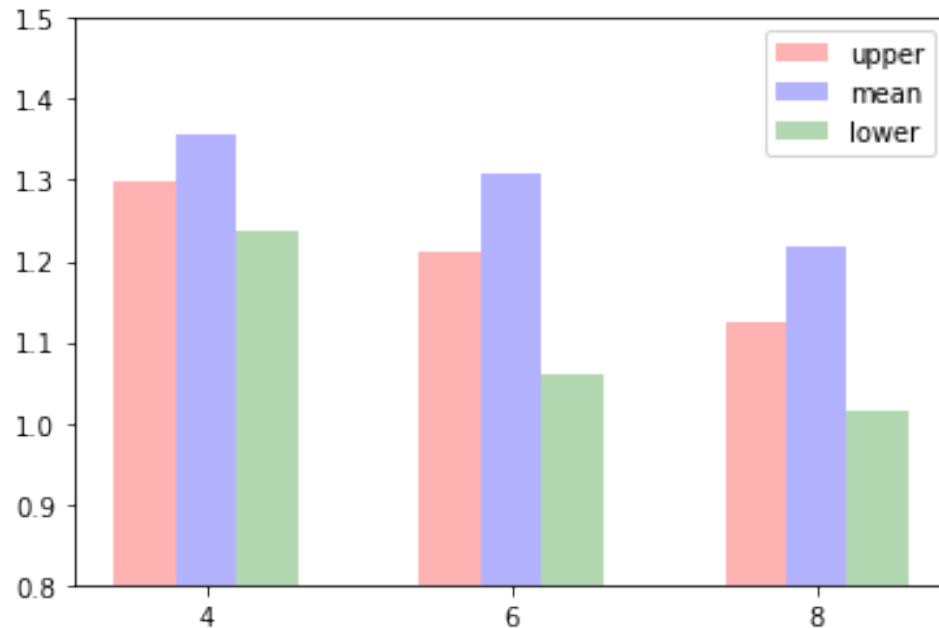
A. 확실히 **다른 포트폴리오**를 제시하는 데 성공했다!

**상승** 전망 : 서교동, 우면동, 성수동1가, 한남동

**하강** 전망 : 서교동, 우면동, 신사동, 하월곡동

## 2) Experiment2

세가지 전망에 따른 포트폴리오 수익률



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A. 확실히 **다른 포트폴리오**를 제시하는 데 성공했다!



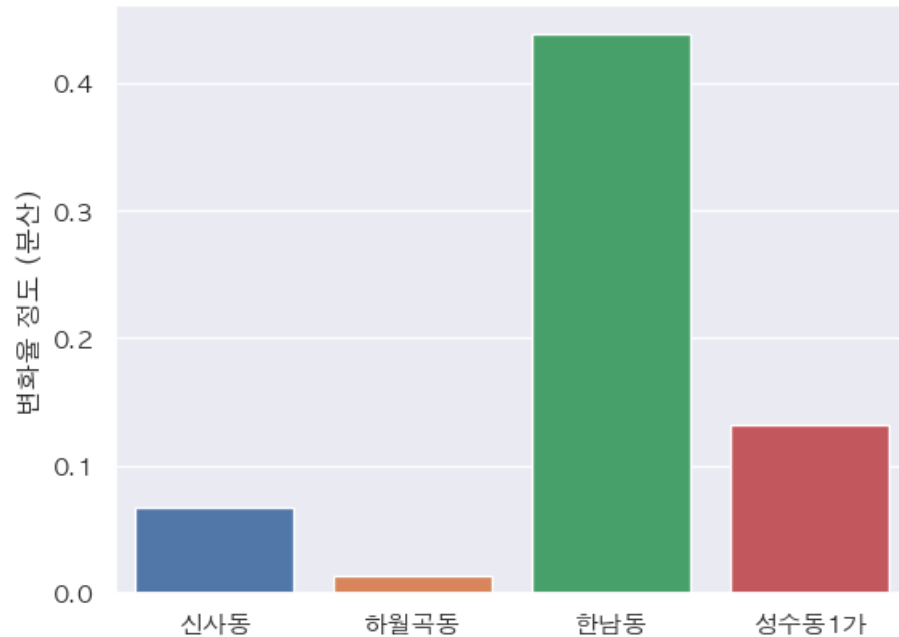
Q. **뽐힌 포트폴리오**가 정말로 상승, 하강장일때 수익률이 좋을까?

A. ....?



## 2) Experiment2

채택된 지역들의 수익률 분산



A. 상승장 일때는 변동이 **높은** 동을,  
하락장 일때는 변동이 **낮은** 동을 뽑았다..!

**상승** 전망 : 서교동, 우면동, 성수동1가, 한남동

**하강** 전망 : 서교동, 우면동, 신사동, 하월곡동

## 4. CONCLUSION



# 1) Limitations

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insufficient data

about 200 dongs have 0 monthly for more than 20 months

impact of economic policies

Regulations change drastically according to government and policy

lack of price consistency

## 2) Further Improvements

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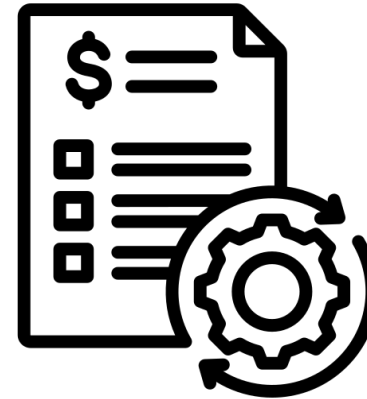
fix assets

can fix assets that  
shouldn't be sold



weight

weight assets  
before optimization



transition  
cost

consider  
transition cost



stock  
portfolio

apply the framework  
to stock portfolio  
-> QUANTUM QUANT

THANK YOU