핀테크(FinTech)와 산업공학

UNIST 경영공학과 발표

카이스트 산업및시스템공학과
김우창

테슬라:
Next Generation of Automobile

Tesla shares skid into a bear market amid a ‘make-or-break year’ for automaker, says market watcher

Keris Lahiff | @kerisalison

Published 22 Hours Ago | Updated 22 Hours Ago

CNBC

돌발 퀴즈 1

- 테슬라가 고전하는 이유는?

Tesla

Hey Tesla, how hard can it be to actually make a car?

The Model 3 is meant to change motoring for the masses, but there's little point in this dream if Musk can't make the car at scale

By **LEON POULTNEY**

Sunday 22 April 2018

Tesla's Disappointing Earnings Highlight Problems in Scaling Production

Steve Banker Contributor ⓘ
Logistics & Transportation
I cover logistics and supply chain management.

As Tesla struggles to exit 'production hell,' buyers complain of delivery limbo

By RUSS MITCHELL SEP 14, 2018 | 5:00 AM | SAN FRANCISCO

Model 3s on a retail lot in Colorado. Paid up customers want to know "where's mine?" (David Zalubowski / Associated Press)

LATEST AUTOS

As Tesla struggles to exit 'production hell,' buyers complain of delivery limbo
SEP 14, 2018

Elon Musk smokes a blunt live on YouTube, Tesla executives quit, and stock drops
SEP 7, 2018

Tesla doesn't release monthly sales figures, except when it kind of does
SEP 6, 2018

BUSINESS NEWS SEPTEMBER 17, 2018 / 11:35 AM / UPDATED 34 MINUTES AGO

Musk says Tesla now in 'delivery logistics hell'

2 MIN READ

(Reuters) - Tesla Inc's (TSLA.O) Chief Executive Officer Elon Musk on Sunday acknowledged that the electric carmaker's problems have now shifted to delivery logistics from production delays, the latest speed bump in its efforts to achieve profitability.

Good news: Your Tesla Model 3 is finally ready. Bad news: It may take weeks to get it serviced

By RUSS MITCHELL JUL 24, 2018 | 5:20 PM | SAN FRANCISCO

Tesla service center in Costa Mesa, Calif. (Allen J. Schaben / Los Angeles Times)

LATEST AUTOS

As Tesla struggles to exit 'production hell,' buyers complain of delivery limbo
SEP 14, 2018

Elon Musk smokes a blunt live on YouTube, Tesla executives quit, and stock drops
SEP 7, 2018

Tesla doesn't release monthly sales figures, except when it kind of does
SEP 6, 2018

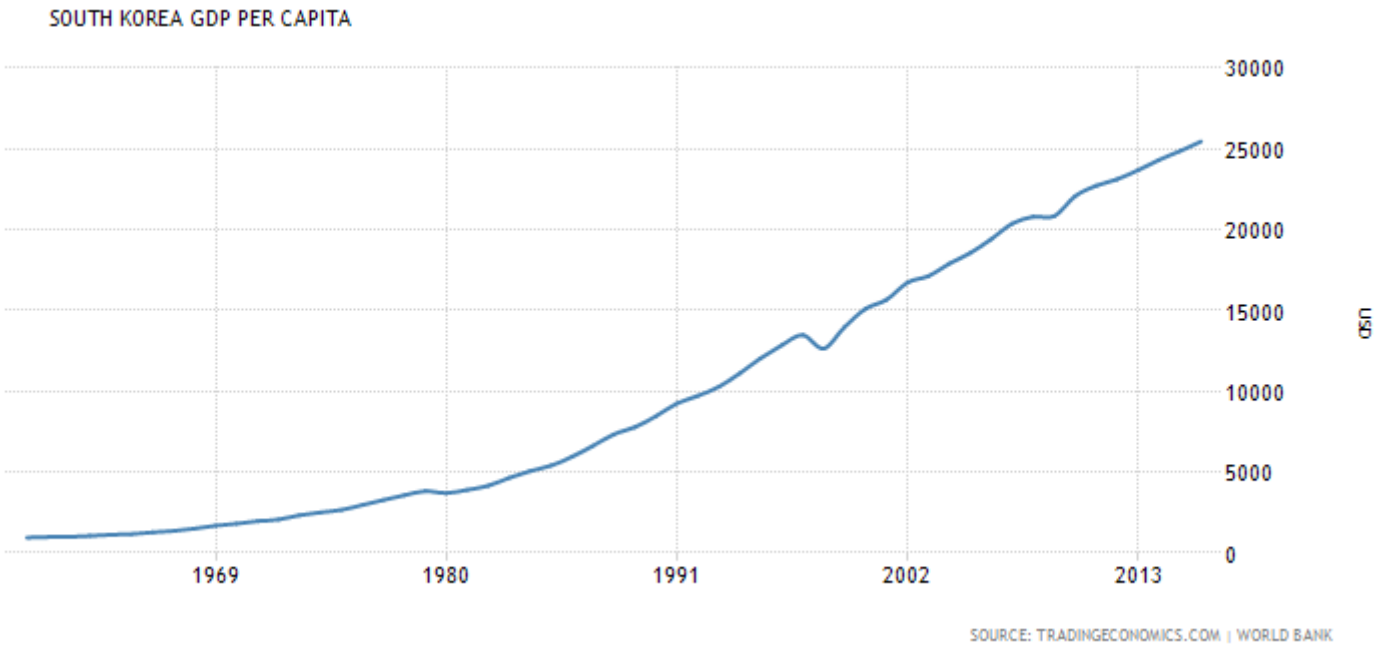
Ford is recalling 2 million pickup trucks after seat belts cause fires

Tesla's production problems extend to its solar roof business, too

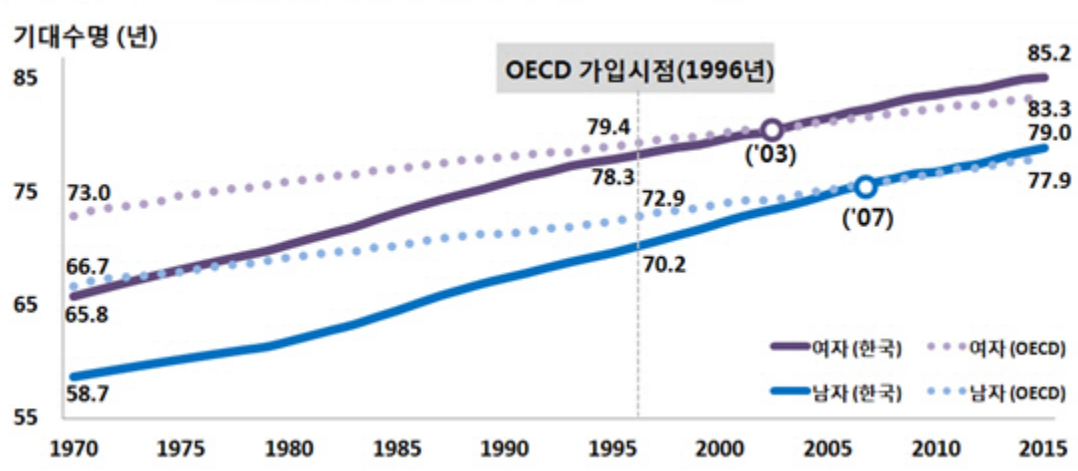
Sources say Elon Musk can't decide what the roof tiles should look like.

Rachel England, @rachel_england
08.08.18 in Business

한강의 기적


SOUTH KOREA GDP PER CAPITA
30000
25000
20000
15000
10000
5000
0
USD
1969
1980
1991
2002
2013
SOURCE: TRADINGECONOMICS.COM | WORLD BANK

경제 성장과 함께 늘어난 평균 수명

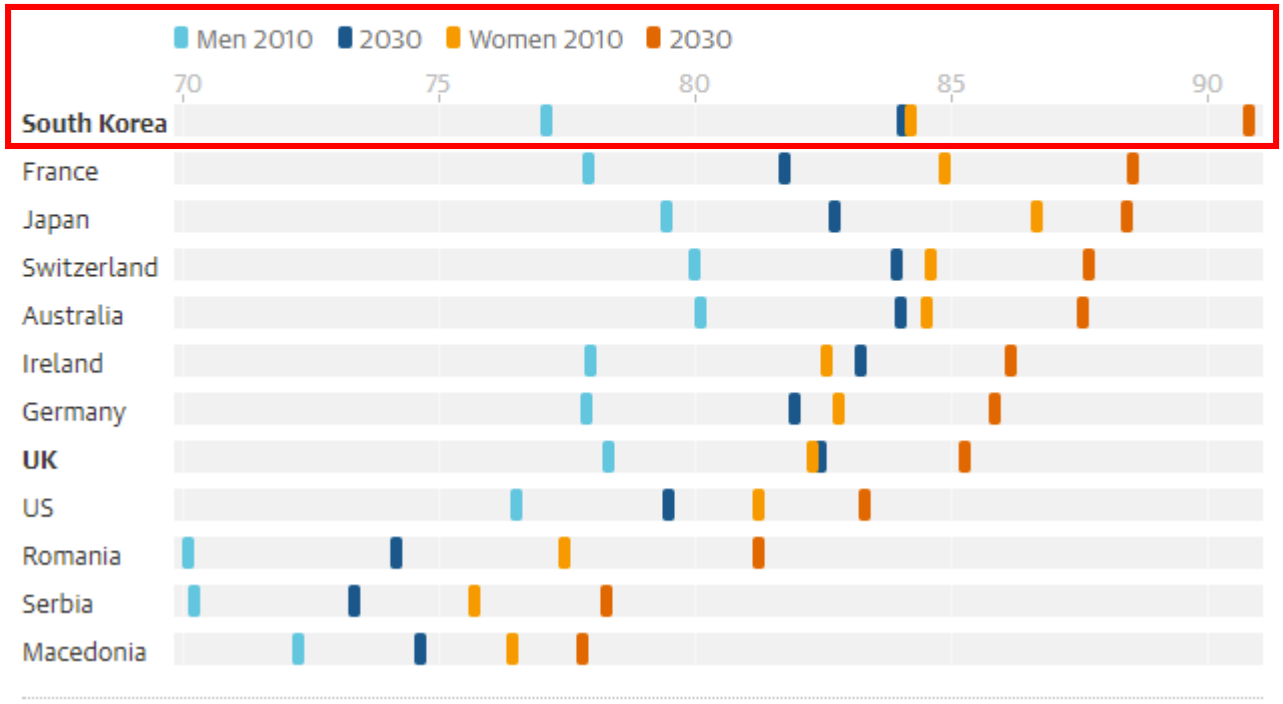


한국의 2030년생: 세계 최고의 장수 집단

Life expectancy forecast to exceed 90 years in coming decades

Among developed nations, South Korea is likely to see the largest increase in life expectancy, with women born in 2030 averaging 90.8 years, 6.6 years longer than those born in 2010

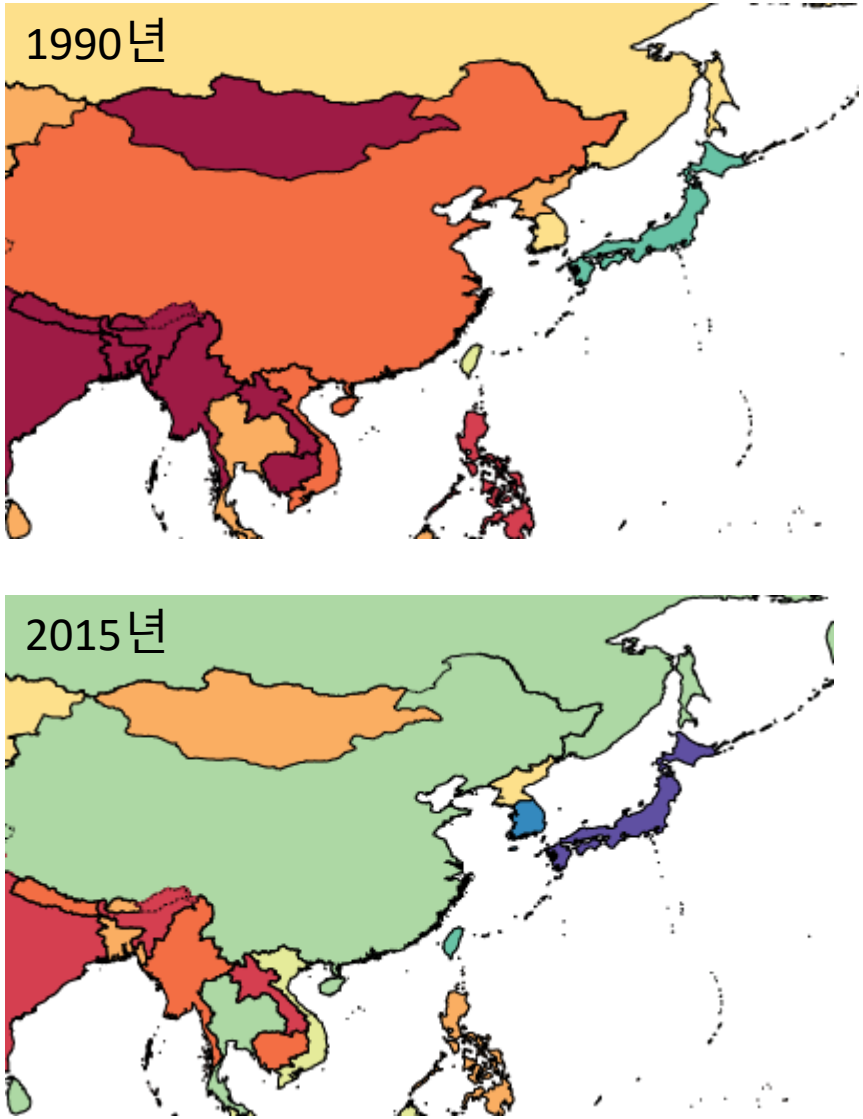
Life expectancy at birth, selected countries



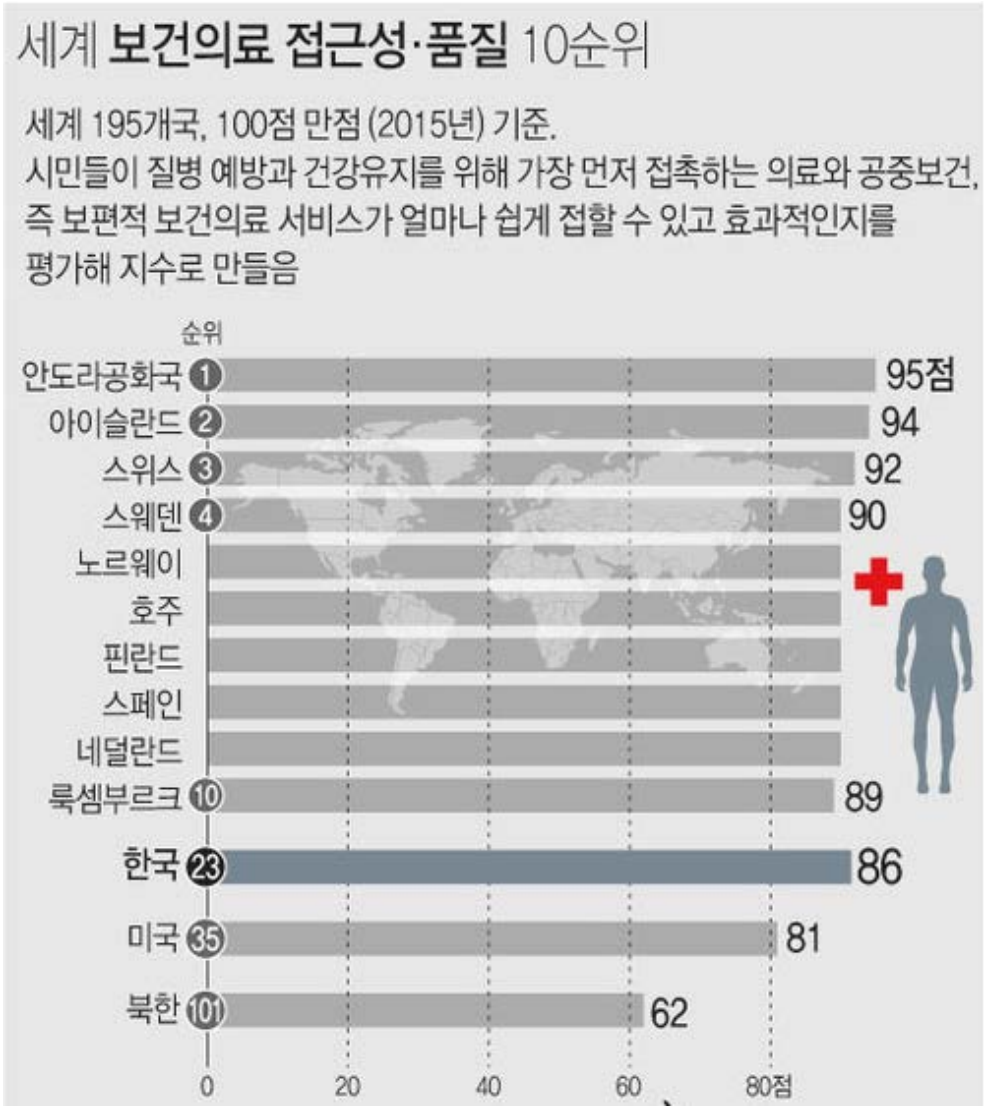
돌발 퀴즈 2

- 한국의 평균 수명이 극적으로 늘어난 이유는?

장수의 원인: 보편적 의료 서비스의 강화



장수의 원인: 보편적 의료 서비스의 강화



돌발 퀴즈 3

- 테슬라가 고전하는 이유와 대한민국 국민 평균 수명의 극적 증가 이유에서 찾을 수 있는 공통점은?

산업공학

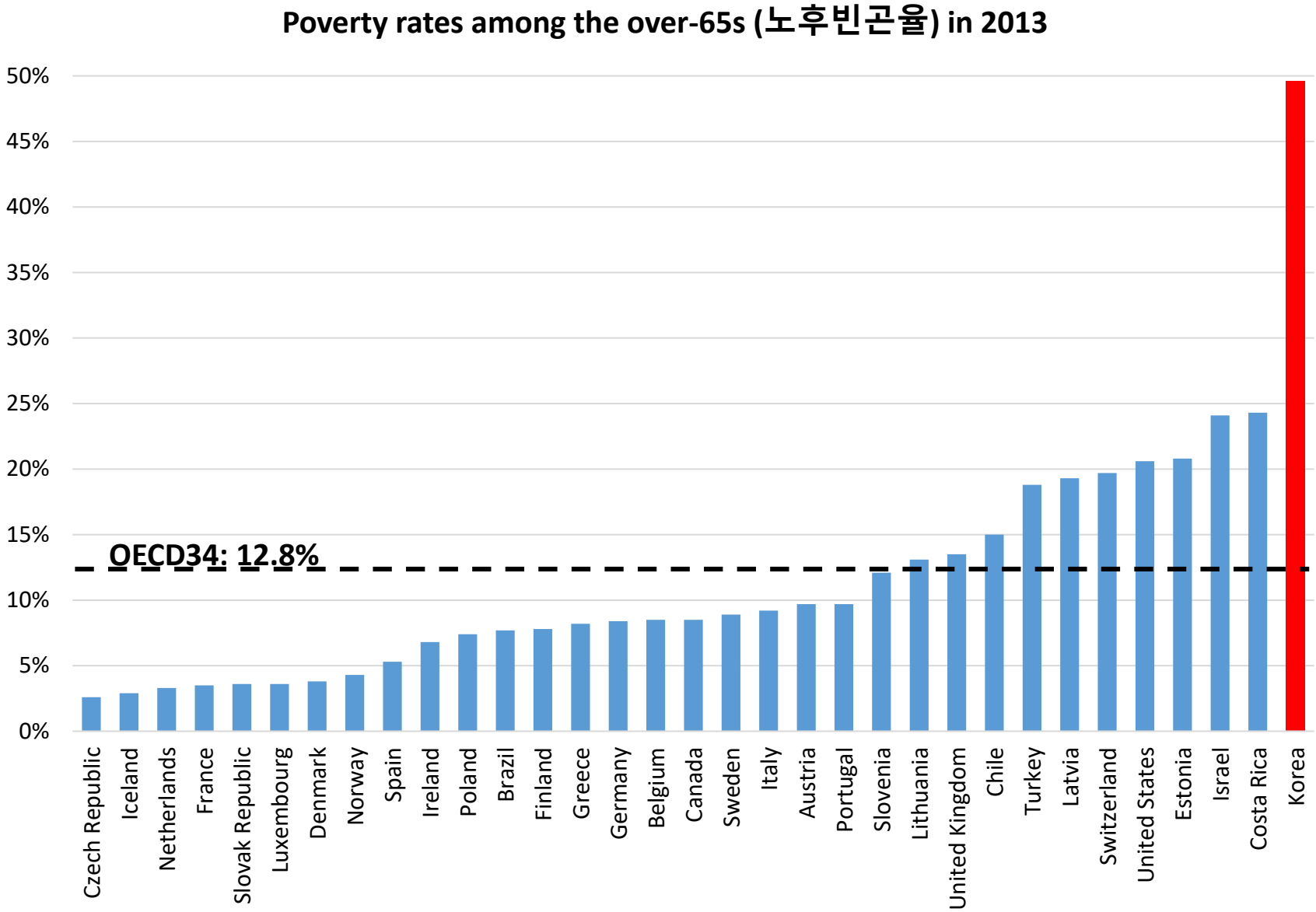
Engineering to scale

장수의 비용

한국 노인빈곤 OECD '최악'...연금소득은 '최하위권'

빈곤율 48.6%로 압도적으로 높아…연금 소득대체율 45.2%로 평균 이하

세계 최악의 노후 빈곤율


Poverty rates among the over-65s (노후빈곤율) in 2013
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
OECD34: 12.8%
Czech Republic
Iceland
Netherlands
France
Slovak Republic
Luxembourg
Denmark
Norway
Spain
Ireland
Poland
Brazil
Finland
Greece
Germany
Belgium
Canada
Sweden
Italy
Austria
Portugal
Slovenia
Lithuania
United Kingdom
Chile
Turkey
Latvia
Switzerland
United States
Estonia
Israel
Costa Rica
Korea

악화되는 상황...

경향신문

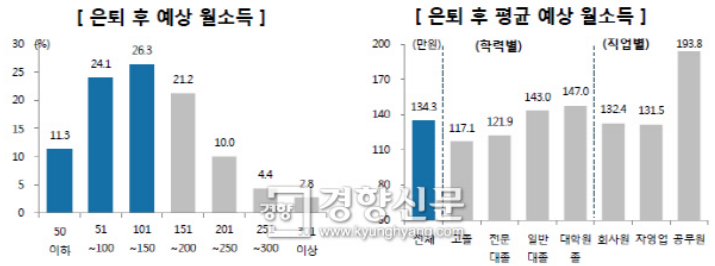
"중산층 10명 중 6명은 은퇴후 빈곤층 될 것"

이호준 기자 입력 2017.12.07. 13:57 댓글 443개

[경향신문] 우리나라 중산층 10명 가운데 6명은 노후준비 부족으로 은퇴 후 빈곤층이 될 가능성이 높다는 조사결과가 나왔다.

NH투자증권 100세시대연구소는 30~50대 중산층 1122명을 대상으로 경제생활과 노후준비 현황을 설문조사한 결과 은퇴 후 소득이 150만원 이하가 될 것이라는 응답자 비율이 61.7%에 달했다고 밝혔다.

현재 부부 기준(2인 가구) 중위소득이 277만원이고, 중위소득의 50%(139만원)에 미치지 못하는 가구를 빈곤층으로 분류하고 있는 점을 고려하면 중산층 10명 중 6명꼴로 노후에 빈곤층으로 전락할 가능성이 크다고 연구소는 분석했다.



중산층 은퇴후 예상 월소득. NH투자증권 100세시대연구소 제공

한강의 기적 -> 최악의 노후빈곤율???
It Doesn't Add Up!!!

Women pray for students sitting exams. Prof Shin believes many people's savings are inadequate because they prioritised spending on their children's education. Photograph: Lee Jin-man/AP

Ironically, part of the reason for their plight may be the cost of supporting their own offspring. "While they were still working," says Shin, "many elderly people were unable to put aside enough savings for later in life because they spent too much on their children's education."

보편적 의료 서비스 : 기대수명 증대

= 보편적 자산 관리 서비스 : 노후 사회 안전망 강화

=

핀테크의 흐름


ChosunBiz
2018. 3. 22 (목)
2018 한국의
주최 : ChosunBiz
뉴스
증권
부동산
정책·금융
기업
오피니언
마켓
분석과 전망
"자산운용업에서 산업혁명이 일어날 것이다"
미국 프린스턴=정재형 금융증권부장
기사
100자평(0)
+크게
-작게
입력 : 2017.04.28 09:53 | 수정 : 2017.04.28 16:02
"로보어드바이저로 인해 개인별 투자목표를 달성시켜 줄 수 있는 자산관리, 즉 목표기반 투자(Goal Based Investment)가 맞춤형 서비스의 대중화(mass customization)를 가져올 수 있다. 그러면 투자관리(Invest management) 산업에 진정한 산업혁명이 일어날 것이다."(리오넬 마텔리니 교수)
"1차 산업혁명에서는 증기기관으로 옷을 싸게 만들 수 있었다. 2차 산업혁명에서는 포디즘으로 자동차를 싸게 만들었고, 3차 산업혁명에서는 인터넷 혁명으로 정보의 비대칭성을 해결하고 일반 대중도 고급 정보를 공유할 수 있었다. 금융에서의 4차 산업혁명을 얘기하자면, 1~3차 산업혁명처럼 기술이 사람의 지적 역량을 인공지능(AI)로 대체할 수 있다. 극소수의 고액자산가들만 누릴 수 있었던 자산관리 서비스가 일반 대중에게도 가능해 질 것이다."(김우창 교수)

핀테크의 흐름

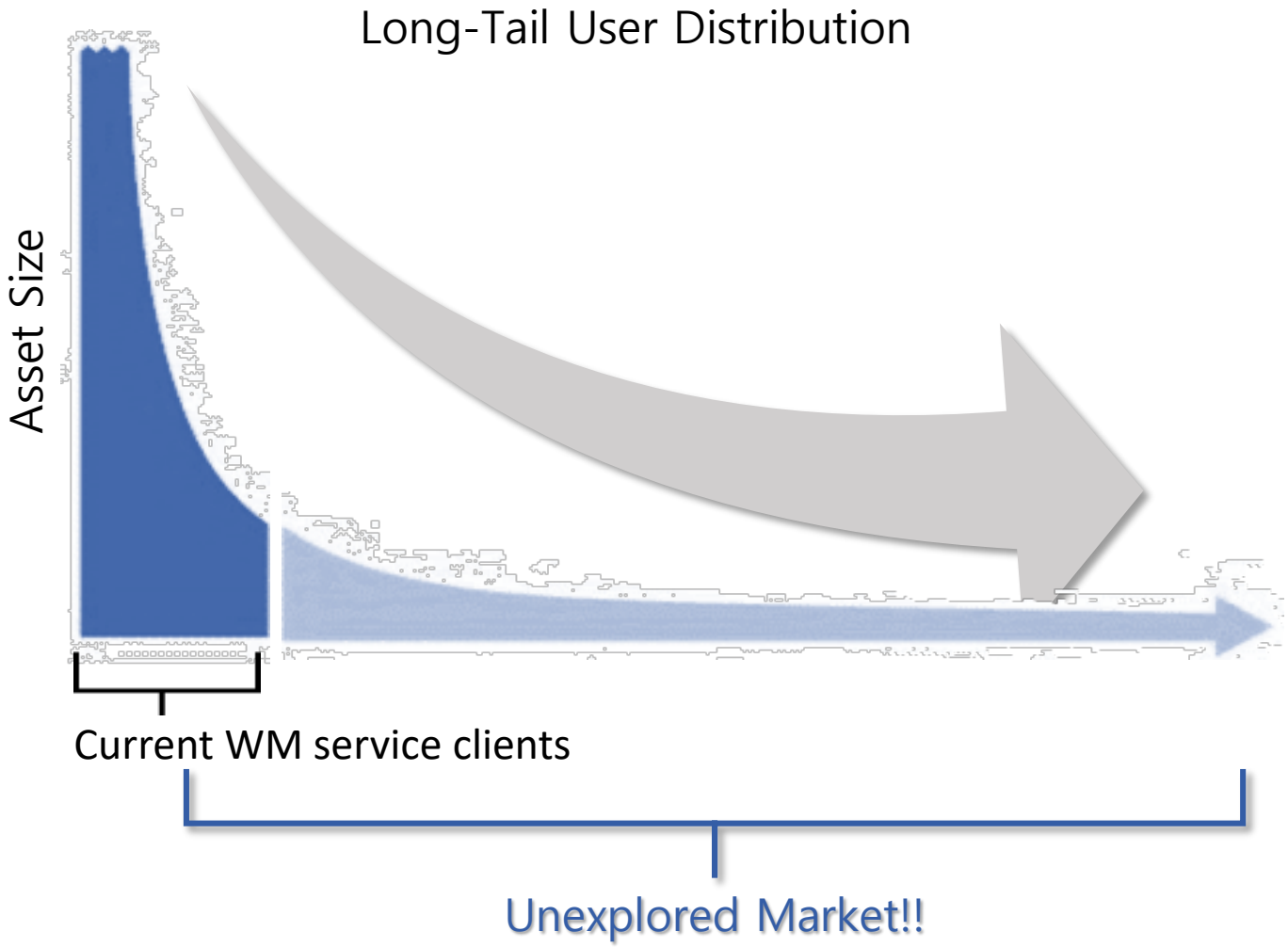
26~27일(현지시각) 미국 프린스턴(Princeton)대에서 열린 '4개 대학 순회 핀테크 컨퍼런스'에서 로보 어드바이저를 통한 개인 자산관리시스템 분야의 세계적인 석학들이 언급한 내용이다. 이번 컨퍼런스는 한국 카이스트(KAIST), 미국 프린스턴(Princeton)대, 중국 칭화(清華)대, 프랑스 에덱(EDHEC) 등 4개 대학이 주최한 것으로 삼성자산운용과 알리바바 자회사인 앤트 파이낸셜(Ant Financial)이 후원했다. 올해 프린스턴대 행사를 시작으로 내년 행사는 카이스트와 칭화대가 공동 개최할 예정이다.

상용화 되기까지는 아직 시간이 좀 더 걸릴 것으로 보이는데 최근 세계 금융공학 학계에서 각광을 받고 있는 분야다. 이번 행사를 주관한 4개 대학이 가장 앞서 있다.

26일 행사에서는 김우창 카이스트 교수와 리오넬 마텔리니 에덱 교수가 기조강연을 했다.

4차 산업혁명 시대의 자산운용산업

By utilizing advanced technologies, we can reduce WM service cost significantly, which allow us to provide service to much larger client base.

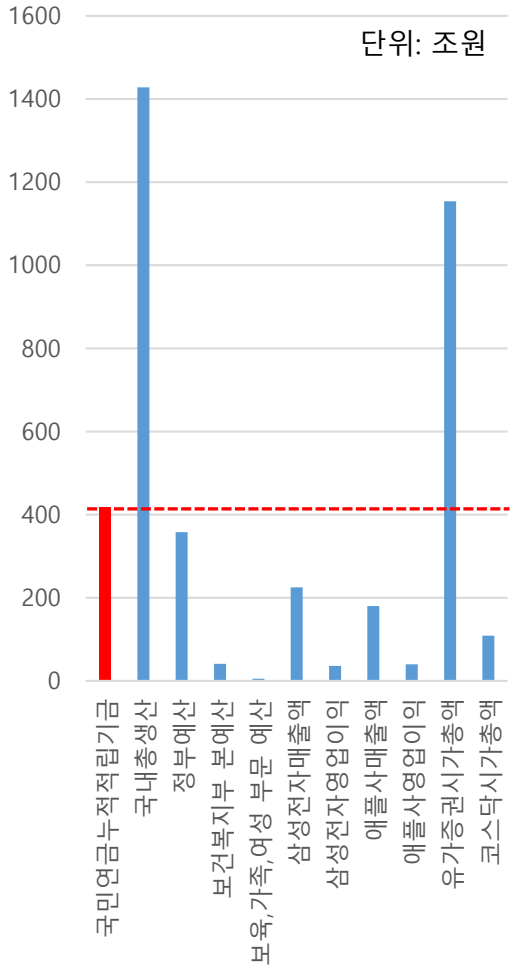


Investing in population growth

연구대상: 천문학적인 규모로 성장한 우리나라의 공적연금

- 2013년 기준 국민연금의 누적적립기금: 약 417조원
  - 2013년 국내 총생산 1,428조원의 약 30%
  - 2014년 대한민국 정부의 예산 357조7000억원의 약 1.2배
  - 2014년 보건복지부 본예산 41조원의 약 10배
  - 2014년 복지 예산 중 보육, 가족, 여성 부문 예산 5조3000억원의 80배
  - 2013년 삼성전자 매출액 228조원의 약 1.8배, 영업이익 36조원의 약 11.5배
  - 2013년 미 애플사 매출액 180조원의 약 2.4배, 영업이익 40조원의 약 10.5배
  - 2012년 국내 유가증권시장 시가총액 1,154조원의 40%
  - 2012년 코스닥 시장 시가총액 109조원의 네 배

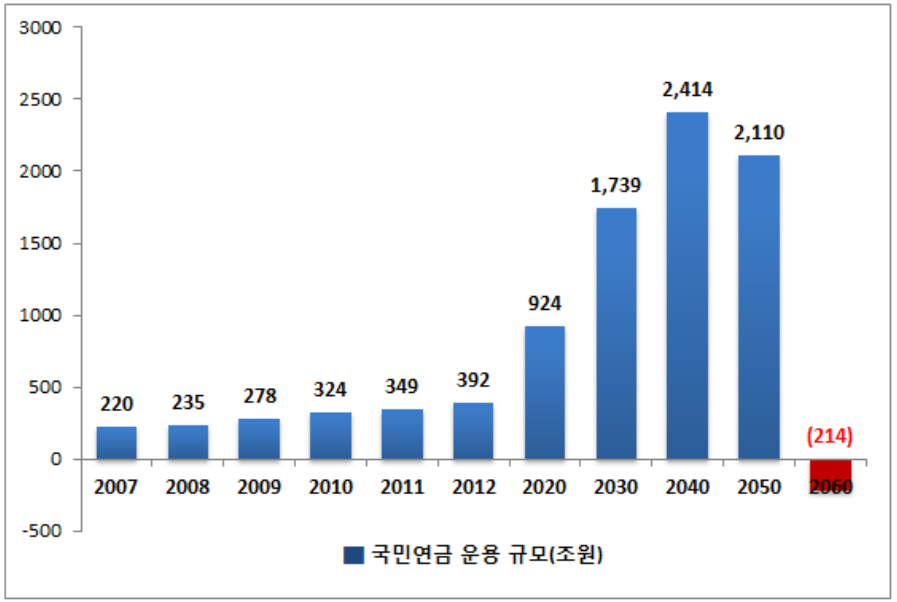
- 국민연금의 적립기금규모는 2040년까지 그 증가세가 지속되어 최대 2,561조원까지 도달
  - 이 시점의 적립기금규모는 국내총생산 대비 약 50%일 것으로 추정



밝지 않은 향후 전망

- 2040년 이후 수지적자가 발생하기 시작할 것으로 추정됨

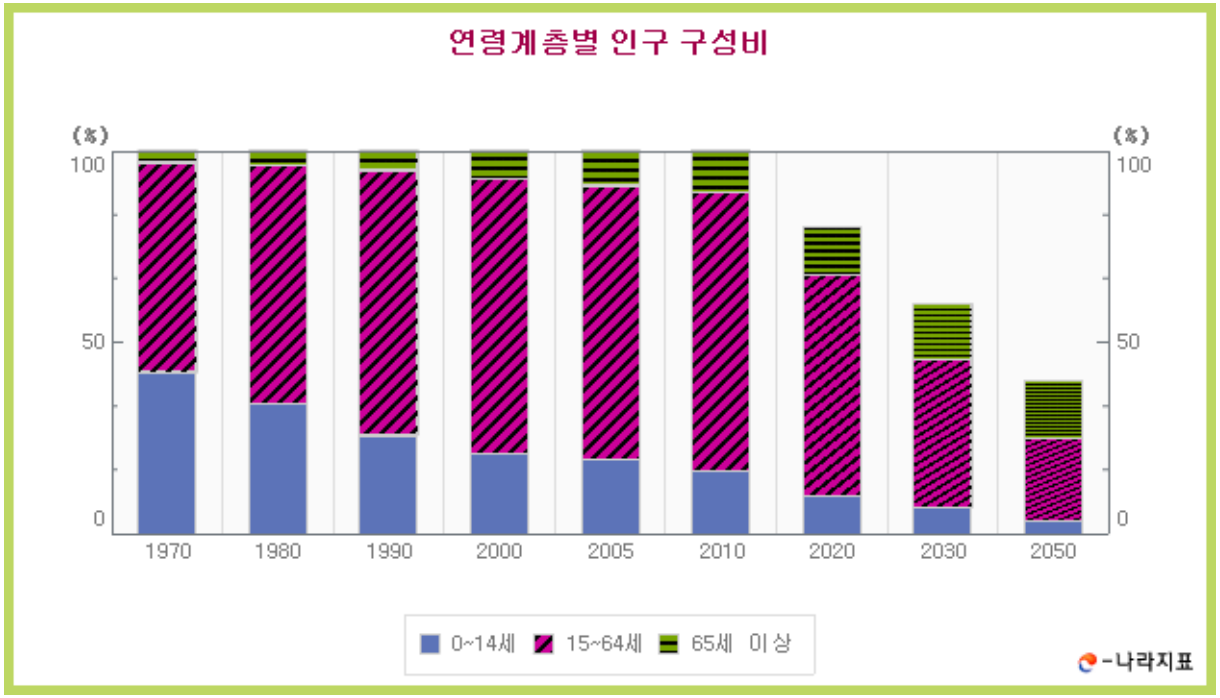
- 최대 규모 도달 시점인 2040년부터 불과 20년 후인 2060년에는 수천조원에 달하는 기금이 모두 소진될 것으로 보임



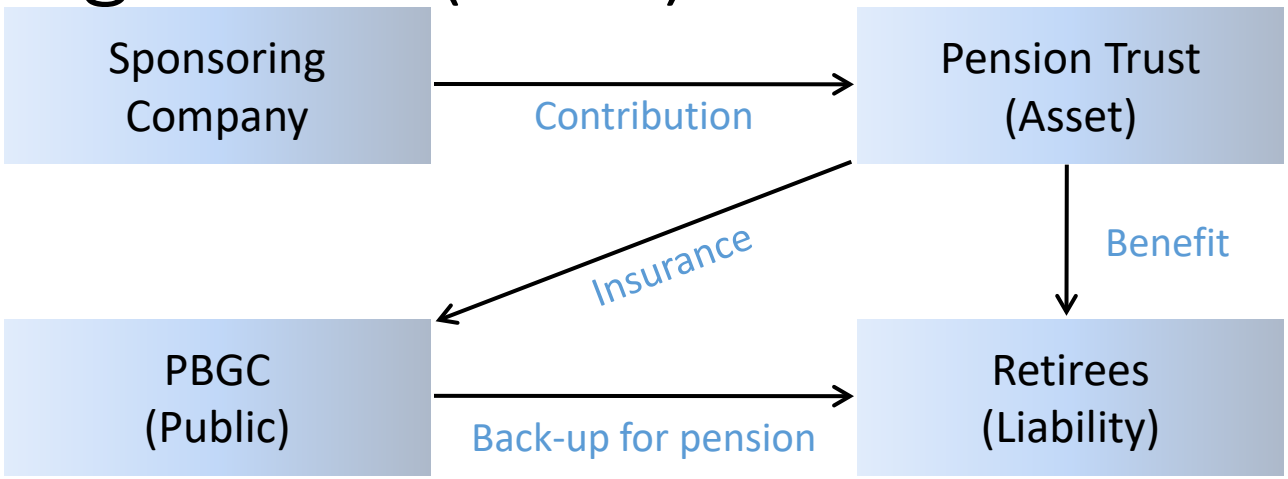
출처: 국민연금운용본부

Why?

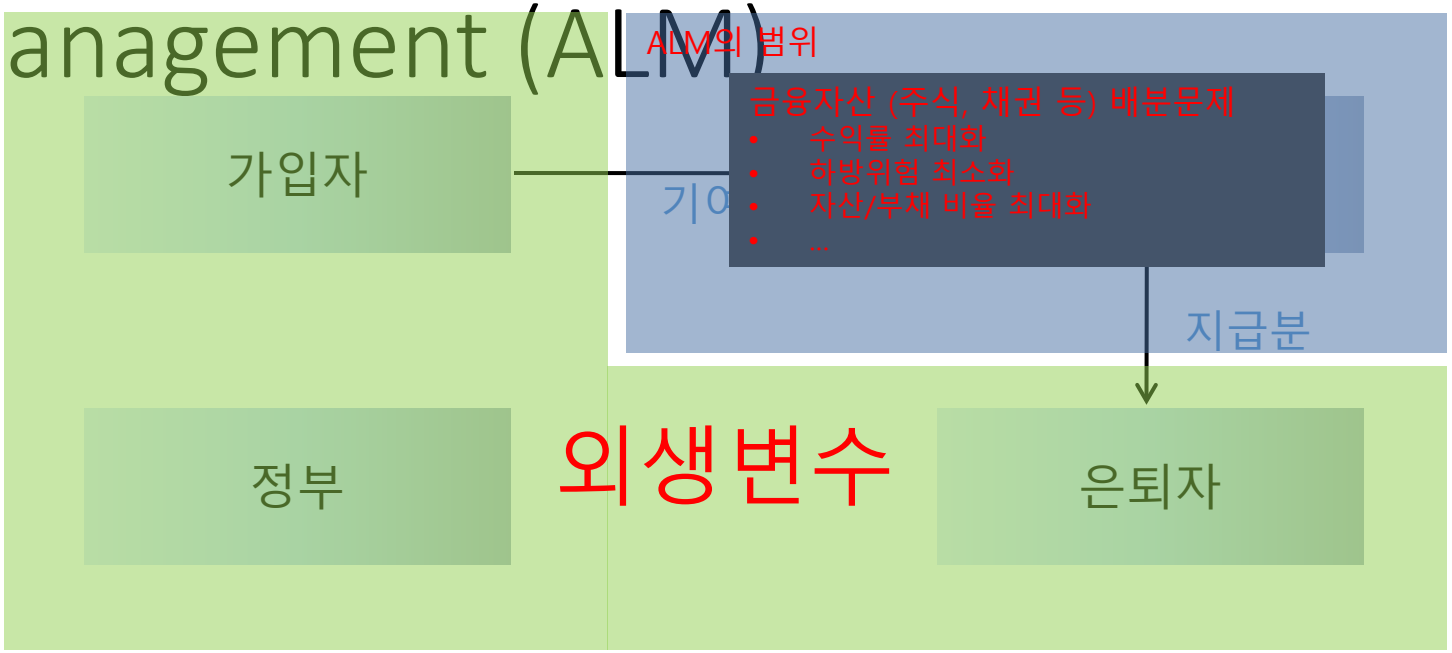
- 급속한 고령화 (2013년 출산율 1.2명)
  - 생산인구의 감소로 인한 기여분 감소 → 자산 축소
  - 은퇴인구의 증가로 인한 지급분 증가 → 부채 증대



기존의 접근 방법:
Traditional Asset Liability Management (ALM)



기존의 접근 방법:
Traditional Asset Liability Management (ALM)



새로운 접근 방법의 필요성

- 기존의 접근법: 좋은 투자 전략을 통한 수익률 증대

- "시장은 시장을 이길 수 없다"
  - 국민연금의 누적적립기금은 유가증권시장 시가총액 40%, 코스닥 시장 시가총액 네 배
  - 국민연금의 투자성과가 주가인덱스, 혹은 경제성장분을 크게 상회하는 것은 상상하기 어려움

- 착안점
  - 국민연금문제의 근본적인 원인: 인구구조변화
  - 출산율이 2.1명으로 증가하면 기금고갈은 발생하지 않음
  - 국민연금은 인구구조 건전화 (출산율 증대)의 직접적인 수혜자: 수혜자 부담의 원칙 적용 가능

- 새로운 접근법: 기존의 ALM + 투자대상으로서의 인구증대 (Investing in Population Growth)

새로운 접근 방법:

Ultimate Question

"투자대상"으로서의 "인구증가에 대한 투자"가
"공적연금 수지개선"에 도움을 줄 수 있는가?

새로운 결정변수: Investing in Population Growth

- 단기수익률 = -100%
- 인구증가유도
- cf) 보육, 가족, 여성 부문 2014년 예산: 5조3000억원 = 기금적립분 1.2%

Two Track Approach

- Track 1: 최적화 기법을 활용한 최적자산배분 문제 풀이
  - Stochastic control
  - Multi-stage stochastic program
- Track 2: 민감도 분석 (Sensitivity Analysis)을 통한 타당성 검증 (Feasibility Test)

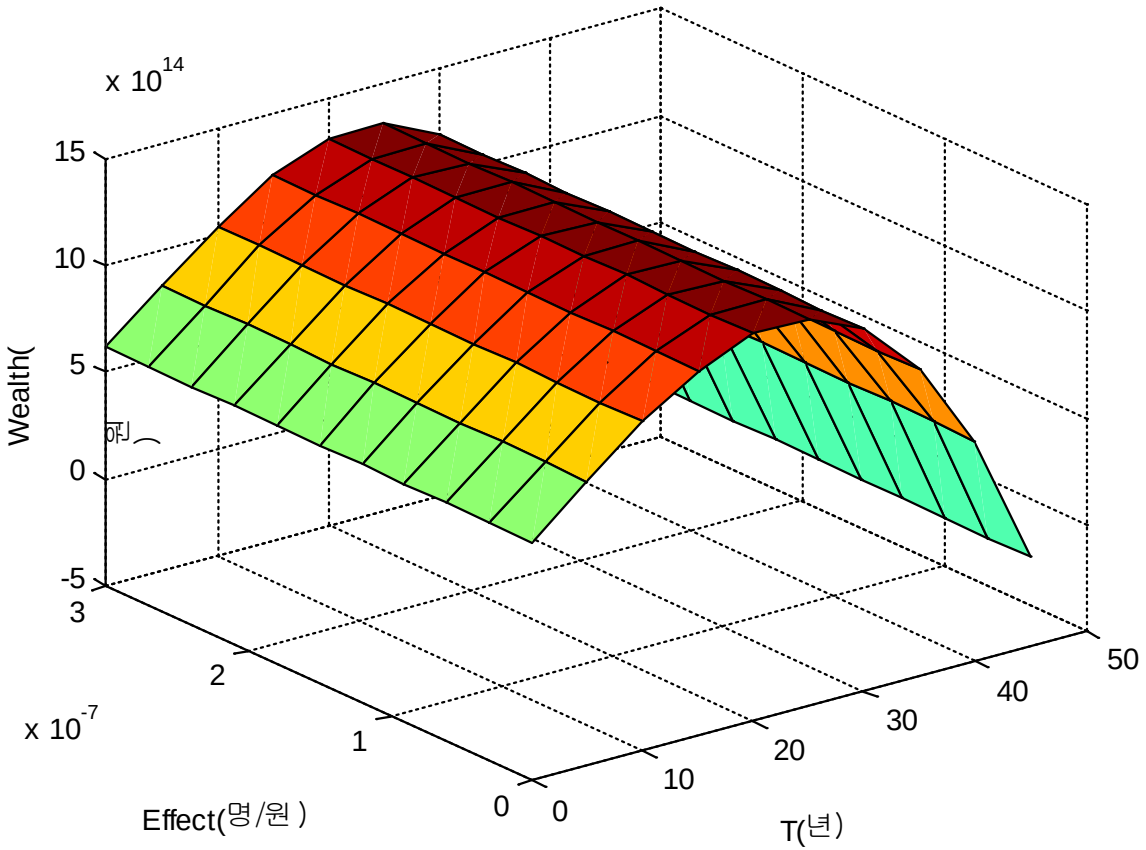
민감도 분석을 통한 타당성 검증: 가정

- 국민연금은 주식과 채권 두 가지의 금융상품에만 투자한다.
- 전체 time span은 50년, 각 time period는 5년으로 계산한다.
- 25세부터 65세까지는 국민연금에 기여하는 연령으로 65세 이후는 연금의 수급대상연령으로 구분한다.
- 이 때, 실제 금액은 현재를 기준으로 평균값으로 계산한다.
- 주식과 채권 수익률, 무위험수익률은 각각 4%, 3.5%, 3%로 일정하다.
- 주식과 채권의 투자 비율은 4:6으로 한다.
- 각 기간마다 연금은 주식, 채권, 인구증가 정책에 투자하게 되며, 인구증가에 투자되는 부분은 미래 인구구조의 변화를 가져오는데 이 인구구조의 변화가 미래 시점에서의 연금의 자산/부채에 영향을 미치게 된다. 즉, t 시점에 연금 자산의 x% 만큼을 인구증가 정책에 투자하게 된다면 t+1 시점의 자산은 다음과 같다.

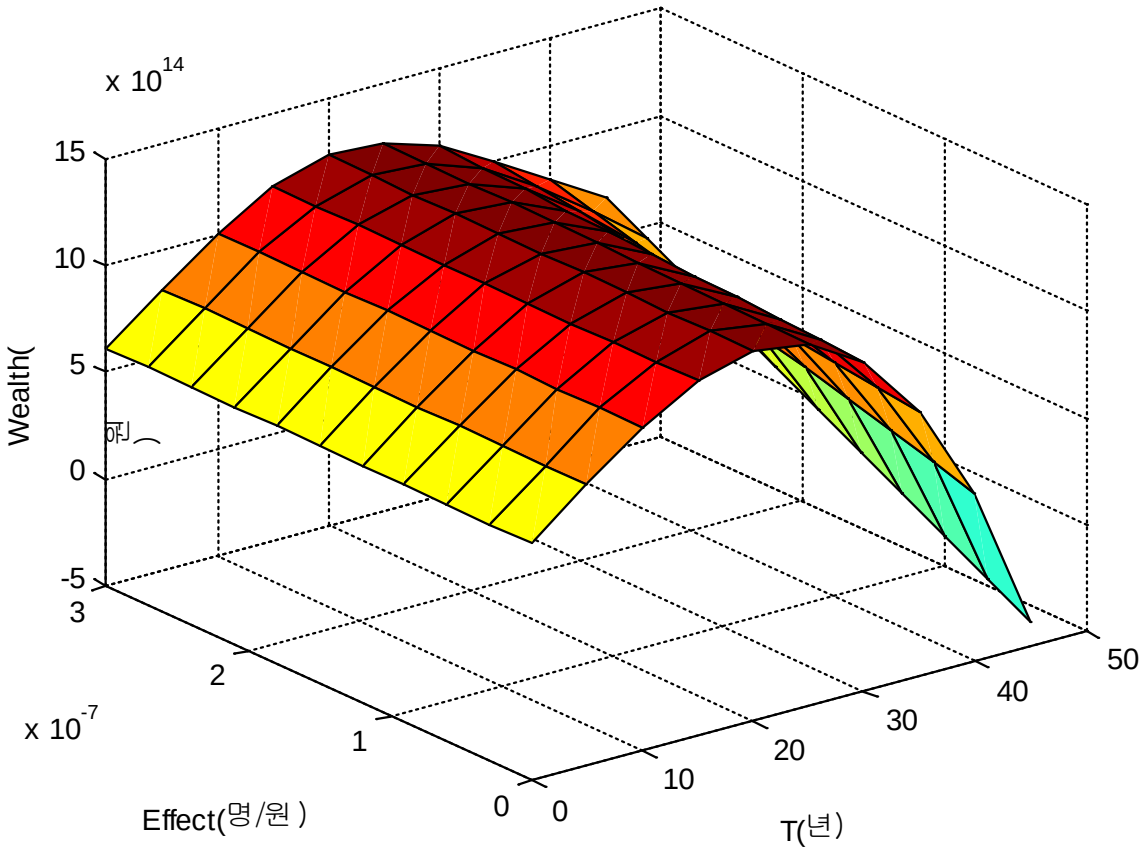
$$W_{t+1} = W_t \times \left(1 - \frac{x}{100}\right) \times (0.6 \times \text{채권수익률} + 0.4 \times \text{주식수익률})$$
$$+1\text{인평균 국민연금 납부금액} \times 25\text{세~}65\text{세 인구수}$$
$$-1\text{인평균 노령연금 수급금액} \times 65\text{세 이상 인구수}$$

- t 시점에 투자한 $W_t \times \left(\frac{x}{100}\right)$의 금액은 투자대비 태어나는 인구수를 α라 할 때 $\alpha \times W_t \times \left(\frac{x}{100}\right)$의 인구를 추가하게 되며, 이 인구는 t+5시점 (25년 뒤)에 국민연금납부 대상 연령(25세~65세) 으로 포함된다. 또한 t+11시점에는 이 인구가 노령연금을 받는 연령(65세 이상)으로 포함된다. 다만 본 연구에서는 50년 후까지에 대해서 계산하였기 때문에 새로 태어난 인구가 노령연금을 받는 연령으로 포함되는 시점은 고려하지 않는다.
- **기타 다른 변수는 현재 국민연금 수치를 그대로 사용한다.**

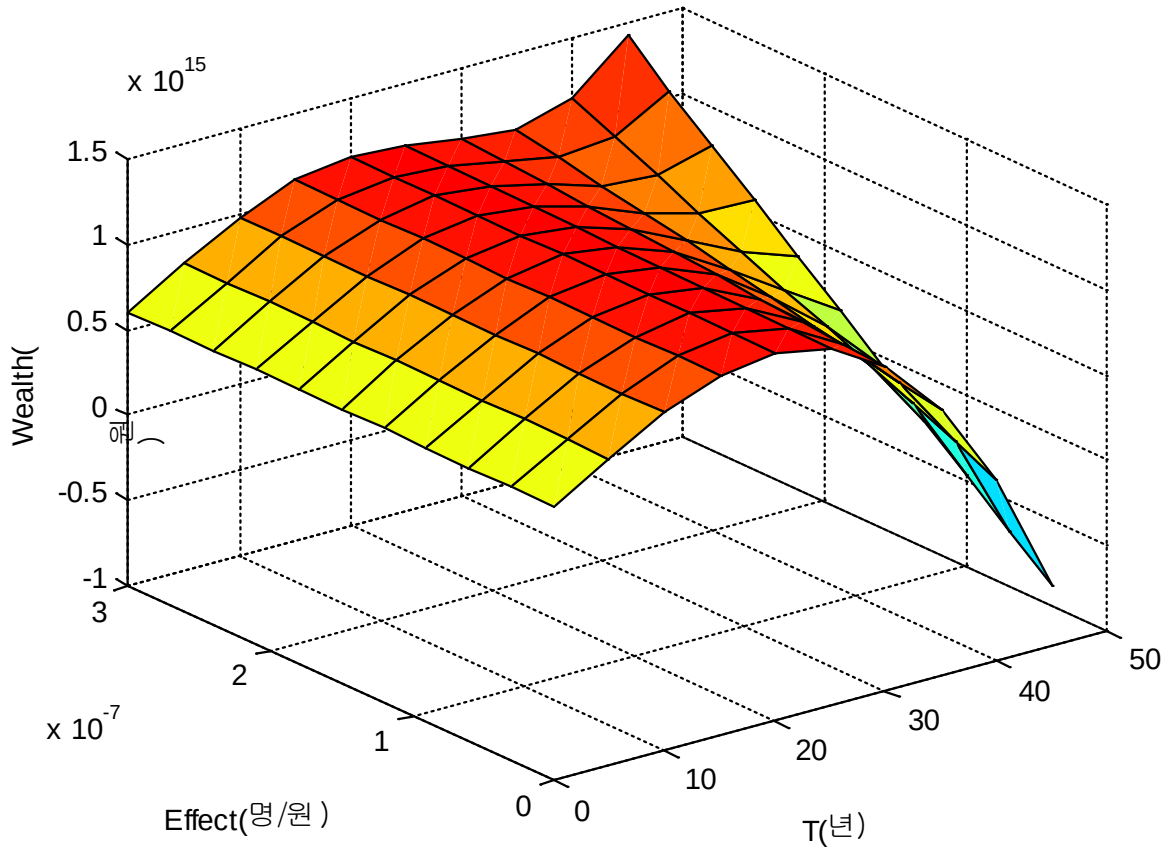
잉여자산 (Surplus): 인구증가에 투자 없음



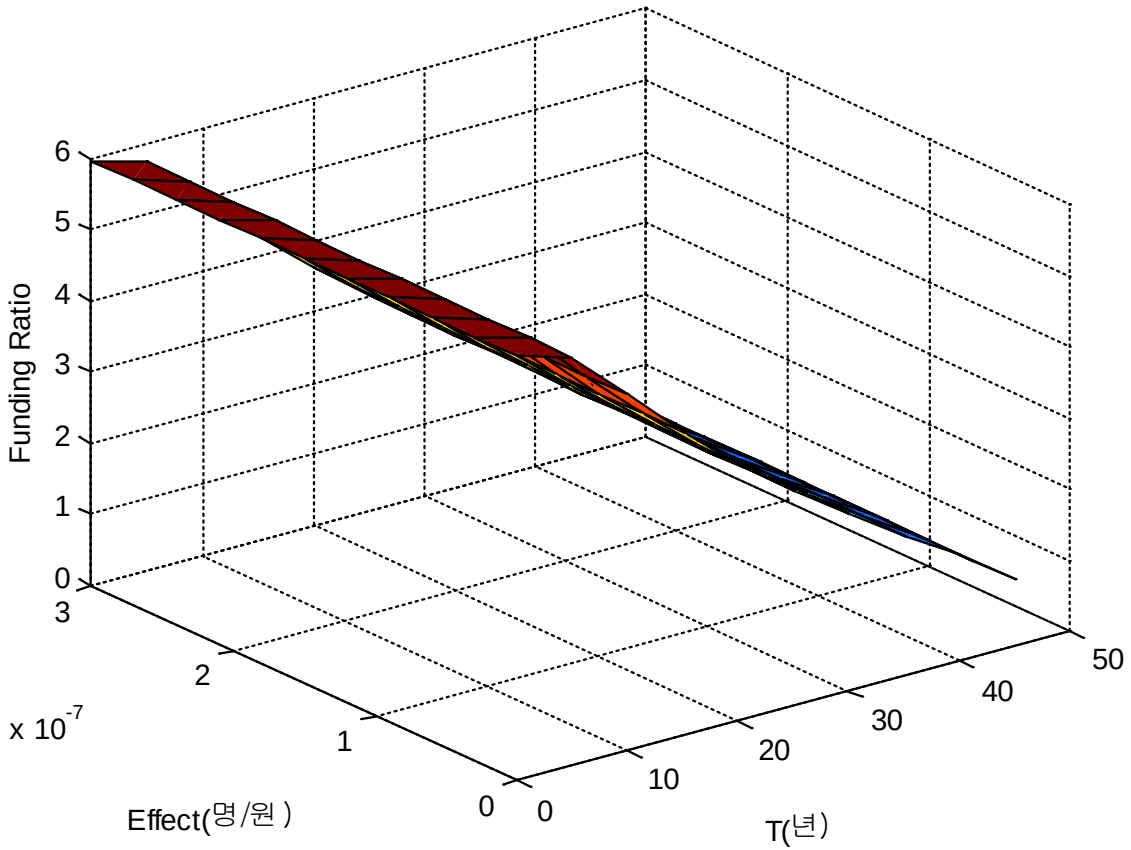
잉여자산 (Surplus): 인구증가에 적립기금의 1.2%씩 투자



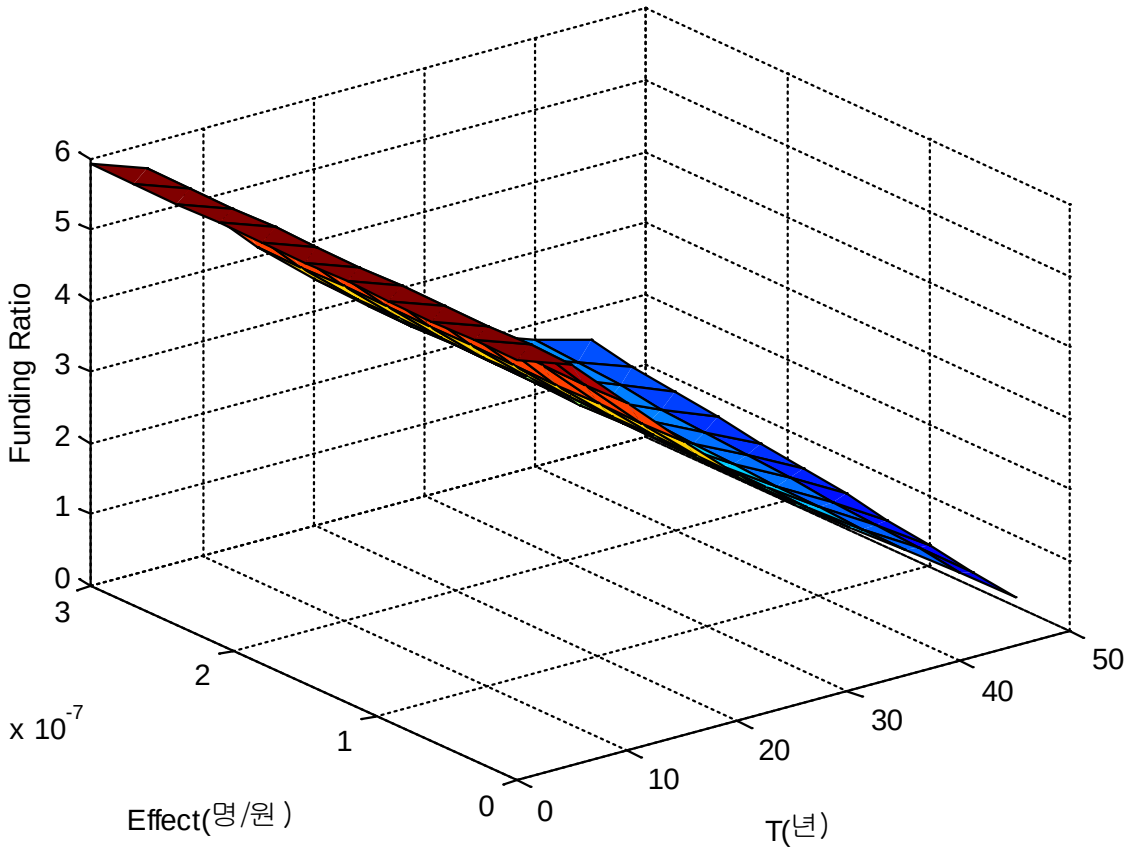
잉여자산 (Surplus): 인구증가에 적립기금의 2.4%씩 투자



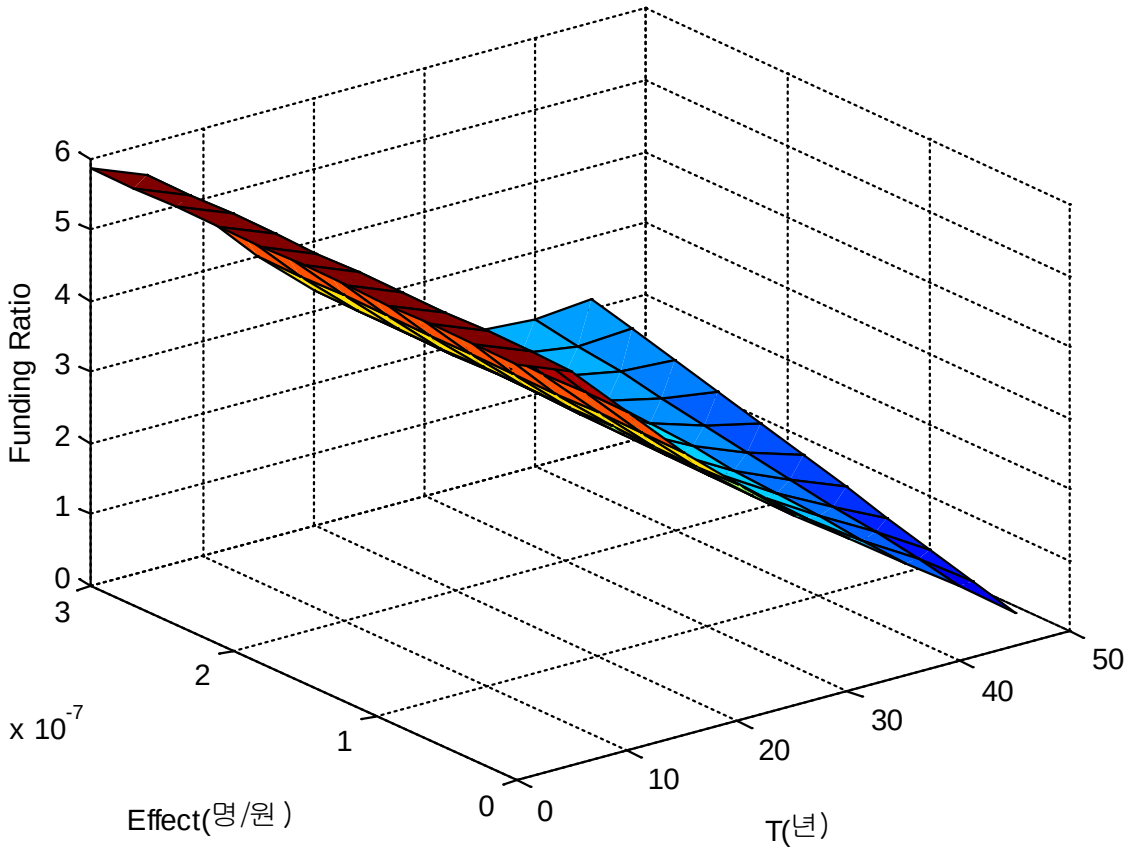
자산–부채비율 (Funding Ratio): 인구증가에 투자 없음



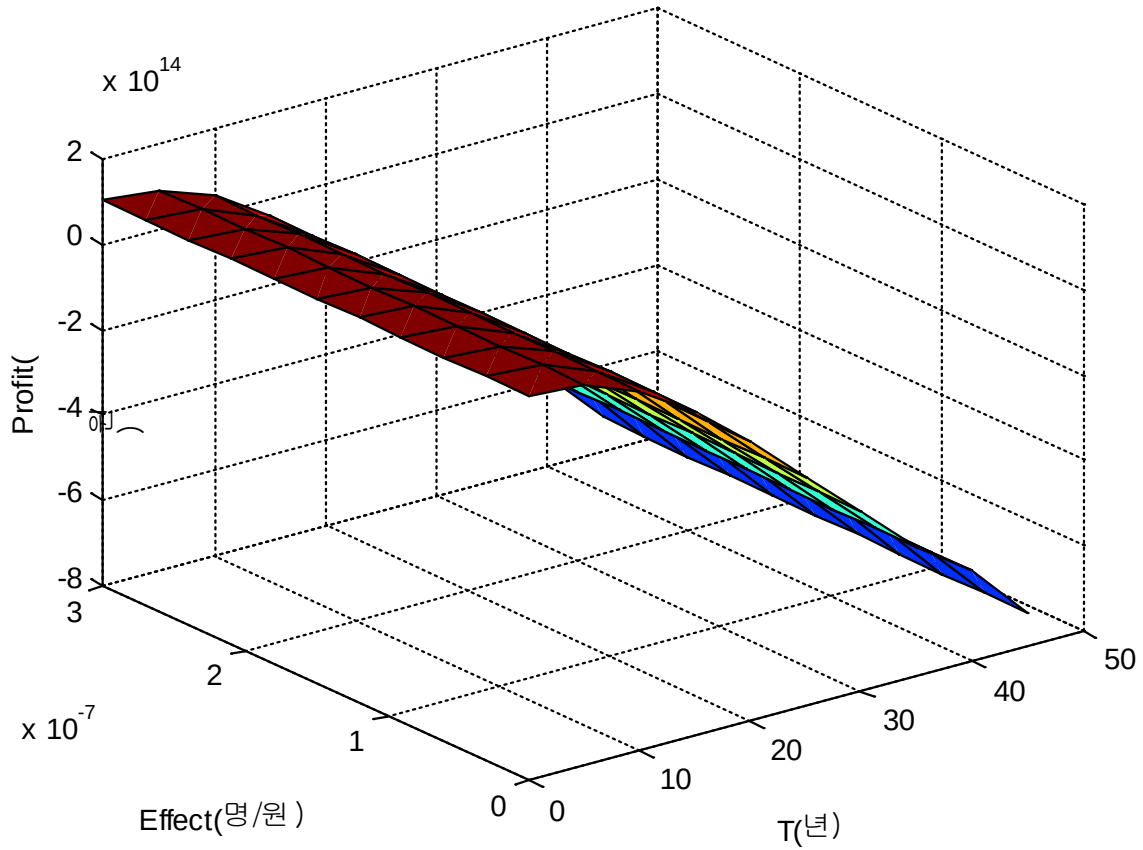
자산–부채비율 (Funding Ratio): 인구증가에 1.2%씩 투자



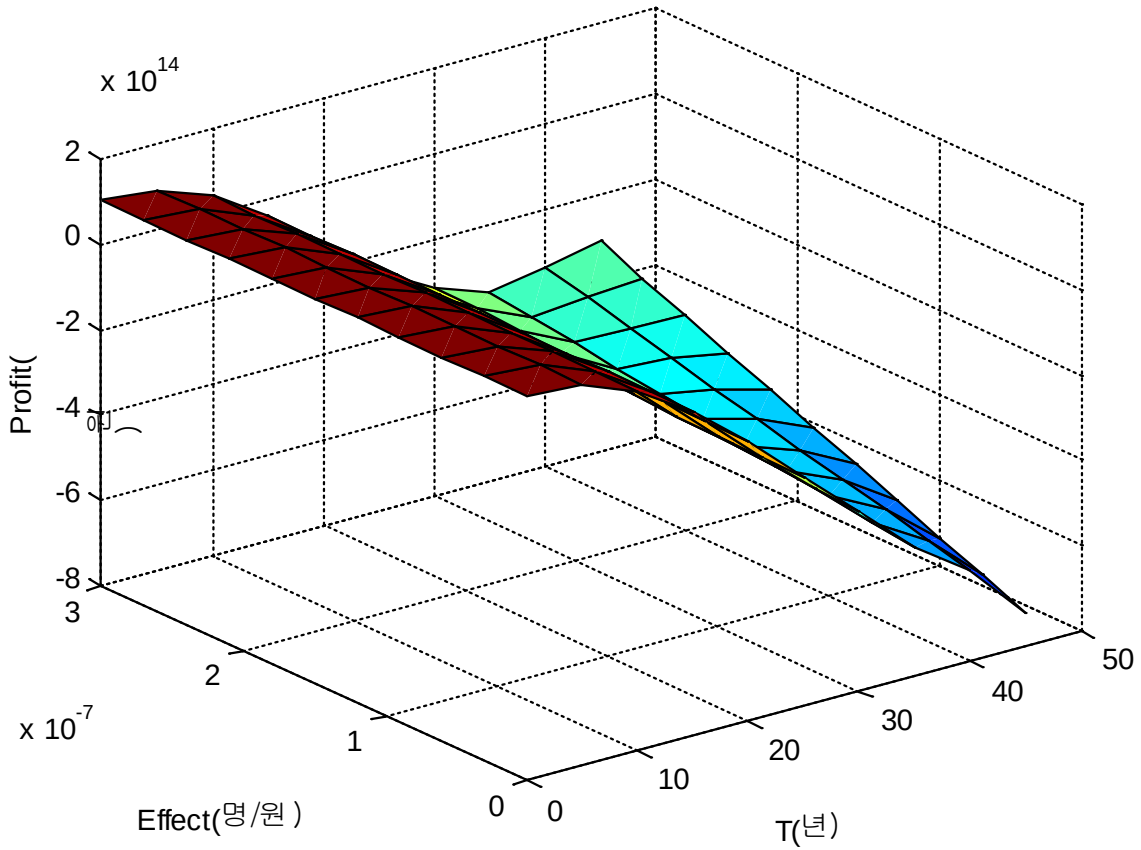
자산–부채비율 (Funding Ratio): 인구증가에 2.4%씩 투자



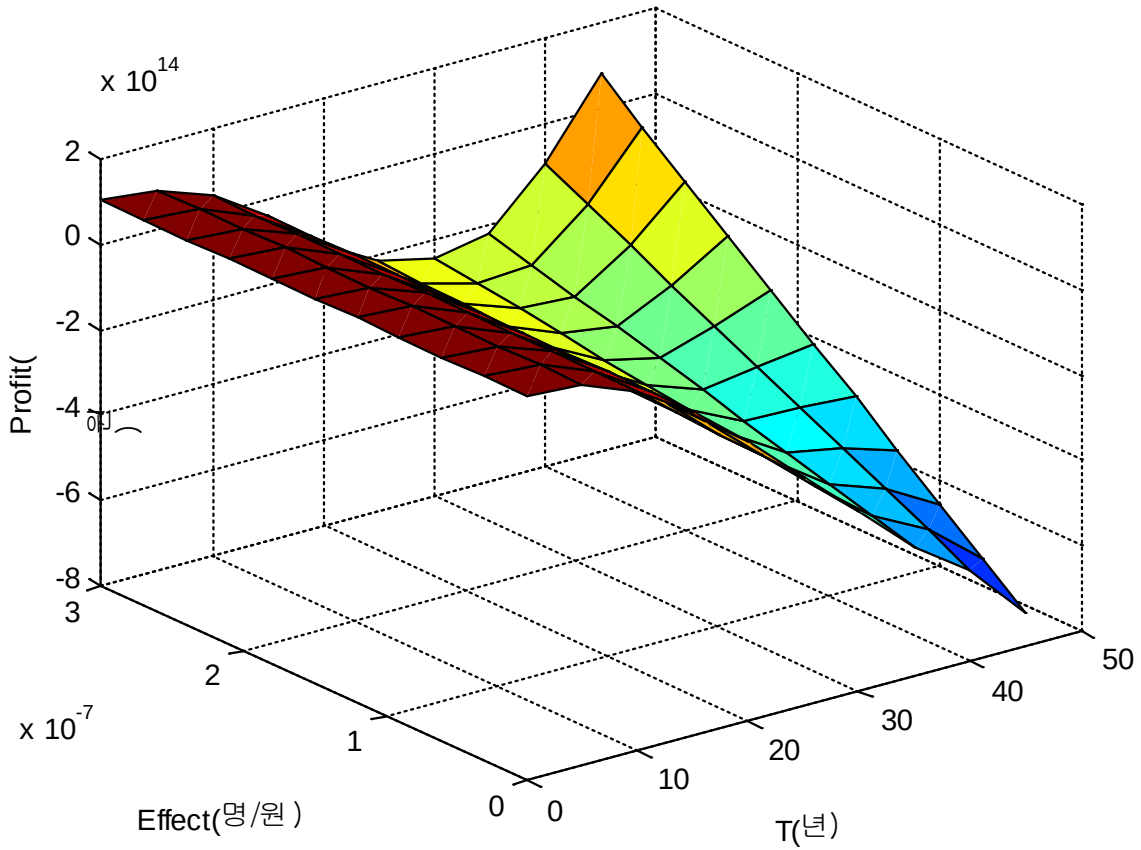
기여–지급 수지: 인구증가에 투자 없음



기여–지급 수지: 인구증가에 1.2%씩 투자



기여–지급 수지: 인구증가에 2.4%씩 투자



민감도 분석: Representative Case

- 인구증가에 대한 투자 1,000만원 당 인구가 2명 이상 증가하는 경우,
- 매해 적립 기금의 2.4%씩을 인구증가에 투자를 한다면,
- 잉여자산(Surplus)은
  - 첫 20년간 상승
  - 추후 20년간 완만히 감소
  - 그리고 마지막 10년은 다시 상승세로 접어들며
- 기여-지급 수지의 경우
  - 첫 15년간은 흑자
  - 추후 30년간 적자
  - 그리고 마지막 5년간 다시 흑자로 접어들게 된다.
- **그리고 기금 고갈은 발생하지 않는다.**

결론

Ultimate Question

"투자대상"으로서의 "인구증가에 대한 투자"가
"공적연금 수지개선"에 도움을 줄 수 있는가?

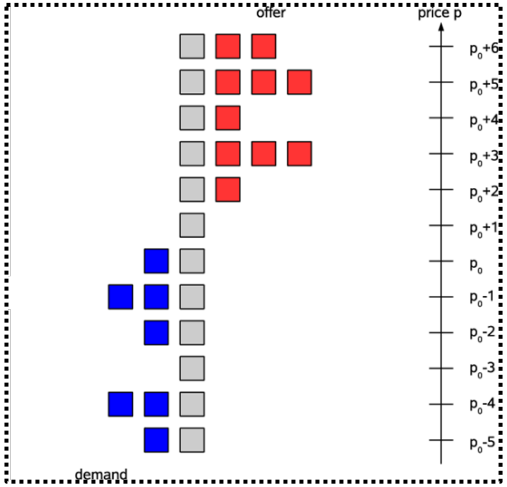
Answer: Yes  **Maybe**

시사점

- 복지는 퍼주기?
- 복지의 투자 수익률?
- “효율적인” 복지?
- 산업공학의 도메인 = 모든 산업 + public sector
- 산업공학은 “큰 문제”를 풀 수 있는 역량을 키우는 학문

An Investment strategy using limit order book information

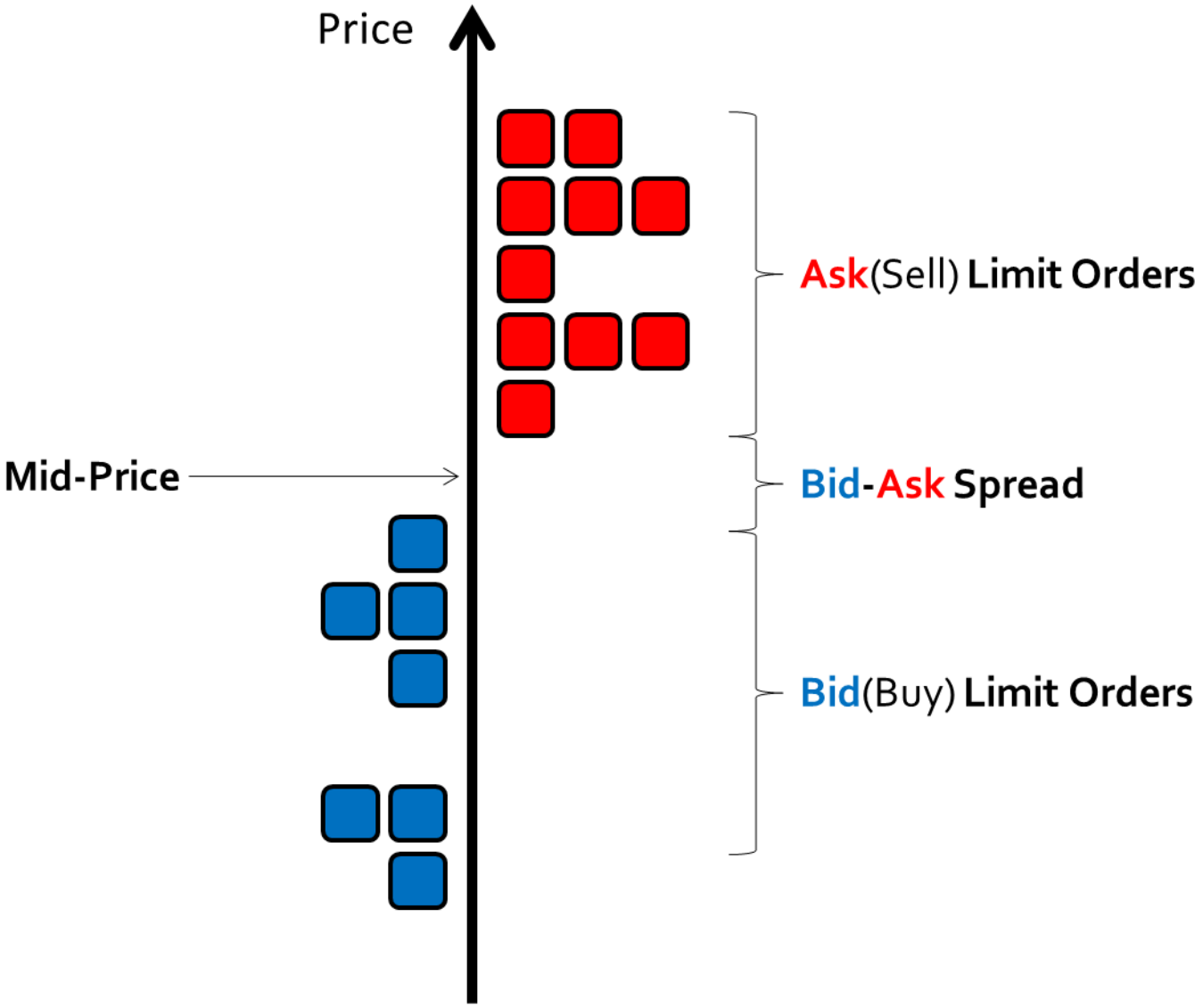
Order-driven Market



- **Limit Order: specify amount & price**
  - Wait in the **queue (Limit Order Book)**
  - To be **executed** against Market Orders
  - Or to be **cancelled**
  - **Increase** in order quantity

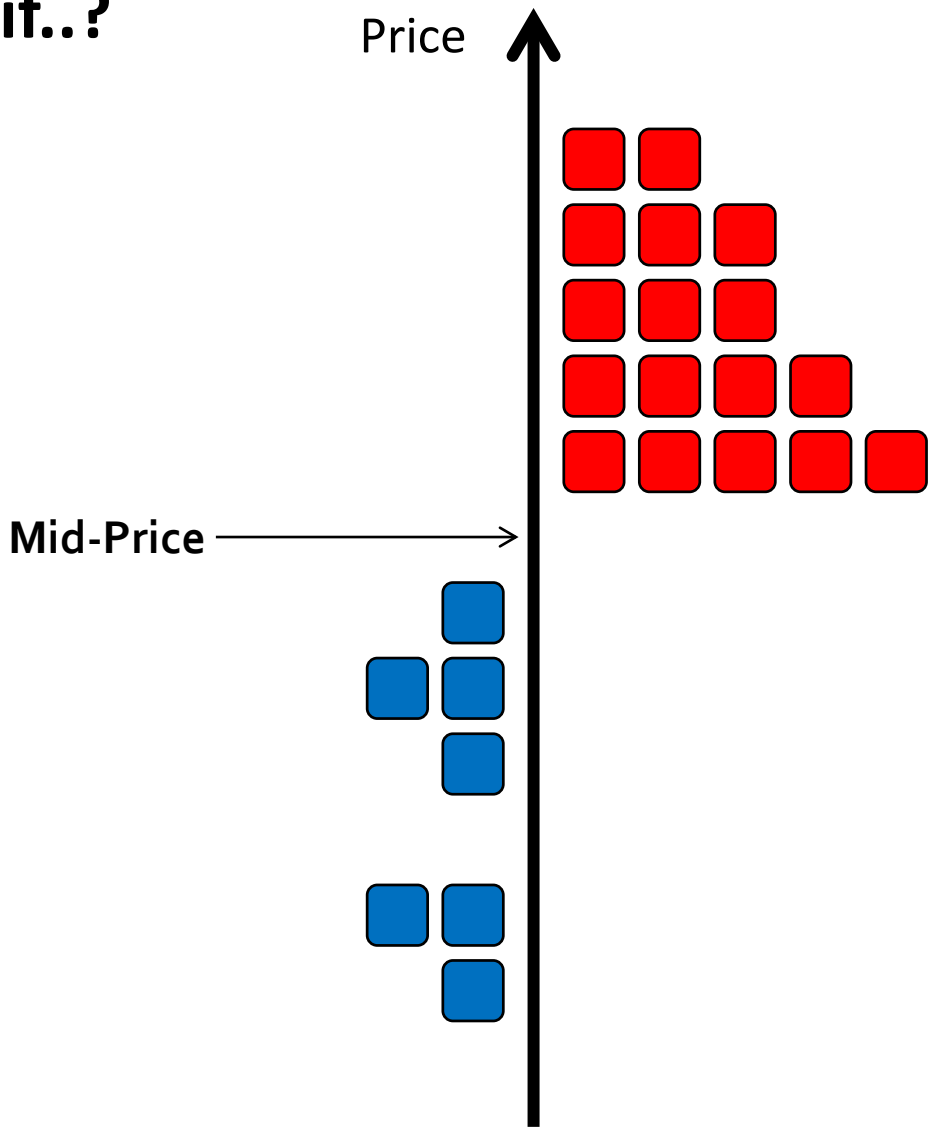
- **Market Order: specify amount**
  - Matches with **the best available price** in LOB
  - **Decrease** in order quantity

- **Cancellation**
  - **Decrease** in order quantity


Price
Mid-Price
Ask(Sell) Limit Orders
Bid-Ask Spread
Bid(Buy) Limit Orders

Limit Order Book – An Example

- **What if..?**



A Stochastic Model for Order Book Dynamics

- In **Order-driven Market**, **Limit Order Book (LOB)** is known to have
  a lot of **information on future price dynamics**

- To utilize the LOB information, active researches on **Stochastic Modeling of LOB** are on-going

- **"A Stochastic Model for Order Book Dynamics" – Cont et al. (2008)**

A Stochastic Model for Order Book Dynamics

- **Model for LOB: Continuous-Time Process $X(t) \equiv \left(X_1(t), \ldots, X_n(t)\right)_{t \geq 0}$**
  - Price grid : {1,…,n}
  - $X_p(t) > 0$: $\left|X_p(t)\right|$ ask(sell) orders at price p
  - $X_p(t) < 0$: $\left|X_p(t)\right|$ bid(buy) orders at price p

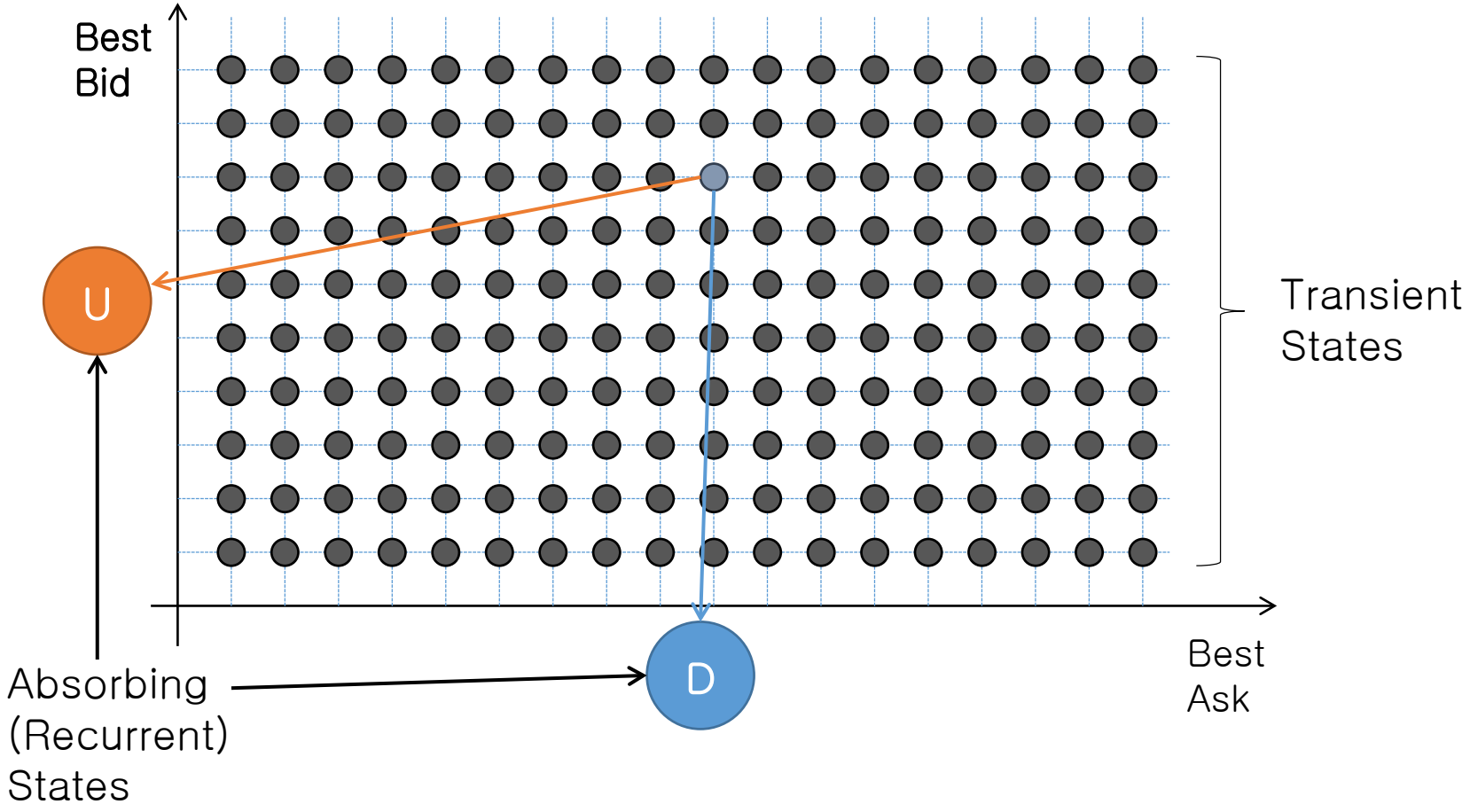
- **Model for Dynamics of LOB: Independent Poisson Processes**
  - **Limit Order** : arrival rate $\lambda(i)$ (i : distance from opposite best quote)
  - **Market Order** : arrival rate μ
  - **Cancellation** : arrival rate $\theta(i)x$ (x : # of outstanding orders at i)

- **Assumption: Every order to be of "Unit" size**
  - unit size = average size of limit order

With this setting, $X(t) \equiv \left(X_1(t), \ldots, X_n(t)\right)_{t \geq 0}$ is a "Continuous-Time Markov Chain"

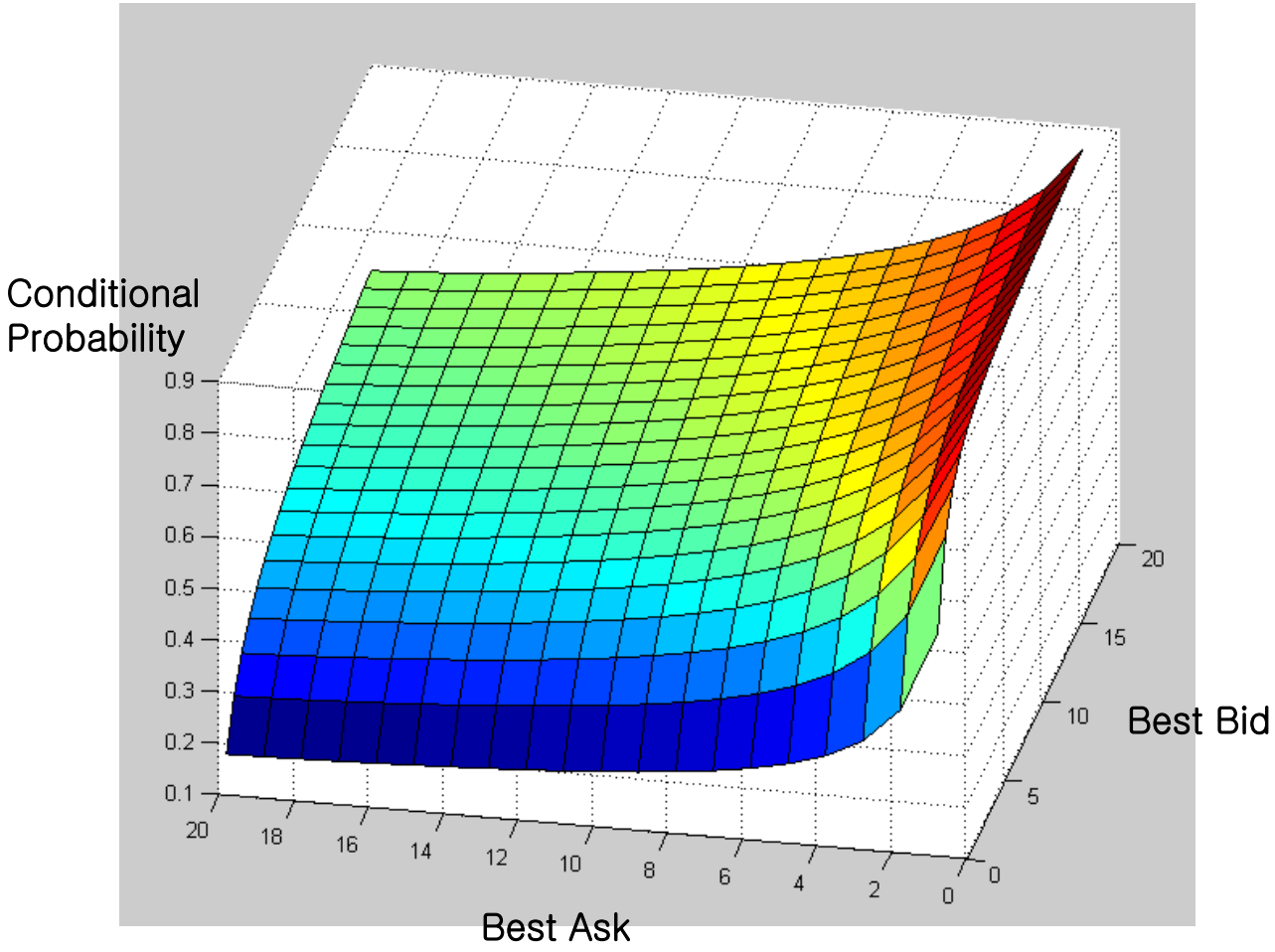
A Stochastic Model for Order Book Dynamics

- Defined an appropriate **Transient** **Discrete-time** **Markov Chain**



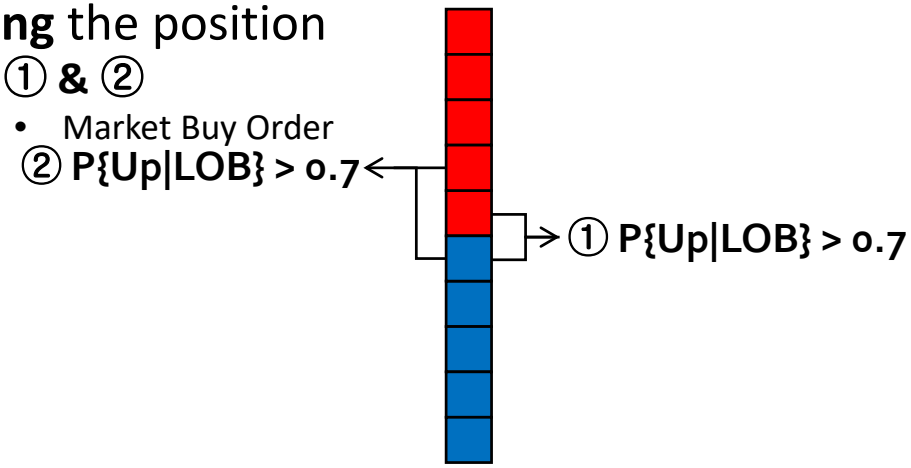
A Stochastic Model for Order Book Dynamics

- **Result: Conditional Probabilities** (Mid-price going UP) (Block size: 20)



A Simple Strategy

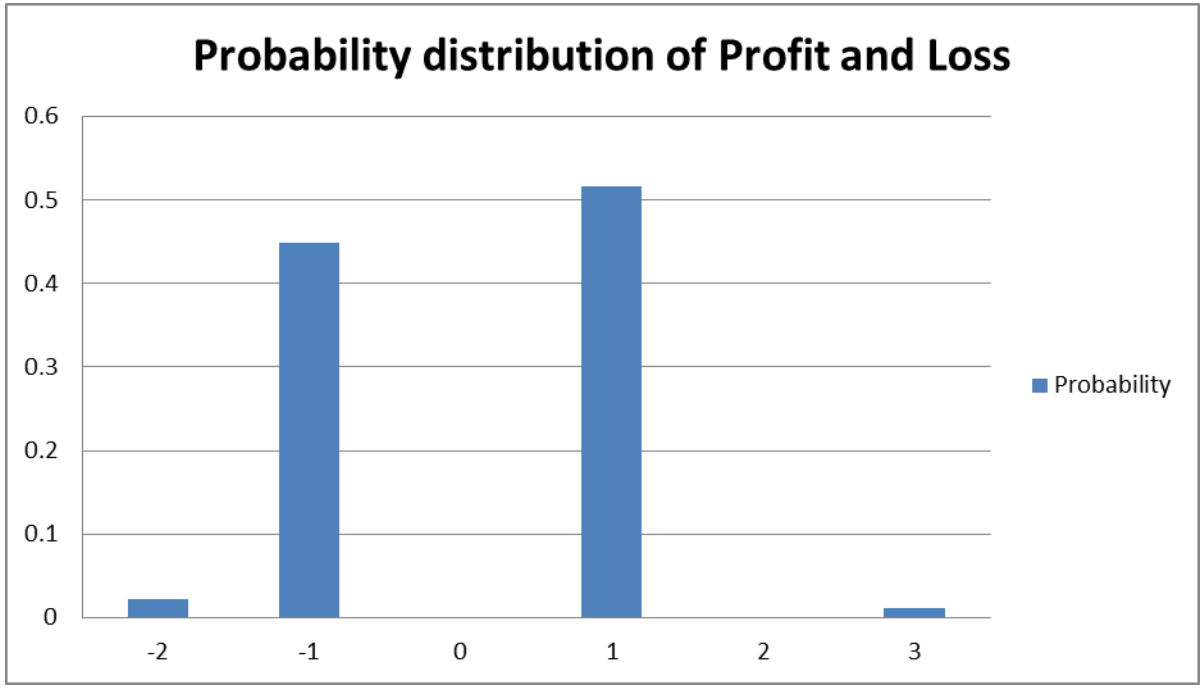
- **Round-trip transaction** to achieve **Statistical Arbitrage**
  - **Entering** the position
    - **If ① & ②**
      - Market Buy Order



  - **Exiting** the position
    - **If 2 ticks UP**
      - Market Sell order → **Earn 1 tick**
    - **If Loss**
      - Market Sell order → **Lose 1 tick**

A Simple Strategy

- **Test on KOSPI 200 Futures**
  - Calibration: 2012/02/21 ~ 2012/02/29, Test: 2012/03/05 ~ 2012/05/07
  - Total # of Transactions: 89, Expectation: 0.06 tick



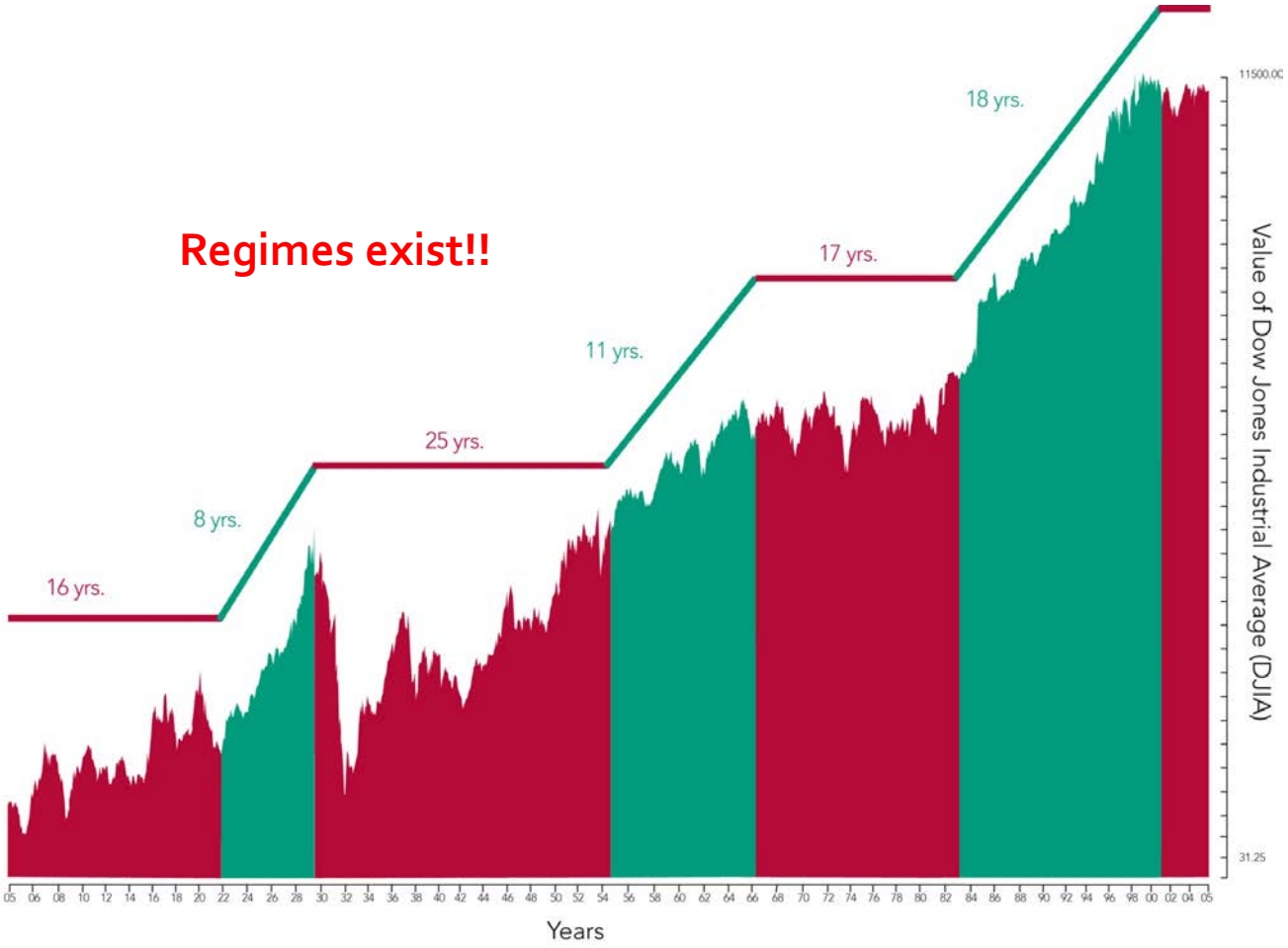
- We can achieve **Statistical Arbitrage** with a very simple strategy

Conclusion

- **LOB** contains useful information on **future price dynamics**
  - We can easily compute the conditional probabilities of mid-price going up (or down) given current LOB shape
- **Statistical Arbitrage** with **simple strategy**
  - Even our simple strategy earns money!

Regime Detection via HMM

Equities Do Grow, But with Booms and Bursts



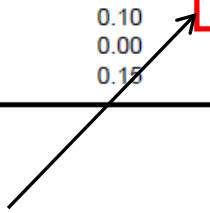
Do not Assume Fixed Correlations over Time

Estimated Correlation Matrix for Asset Returns from a ALM Study for a Large Public Pension Plan

These results do not properly Model Contagion during Market Crashes

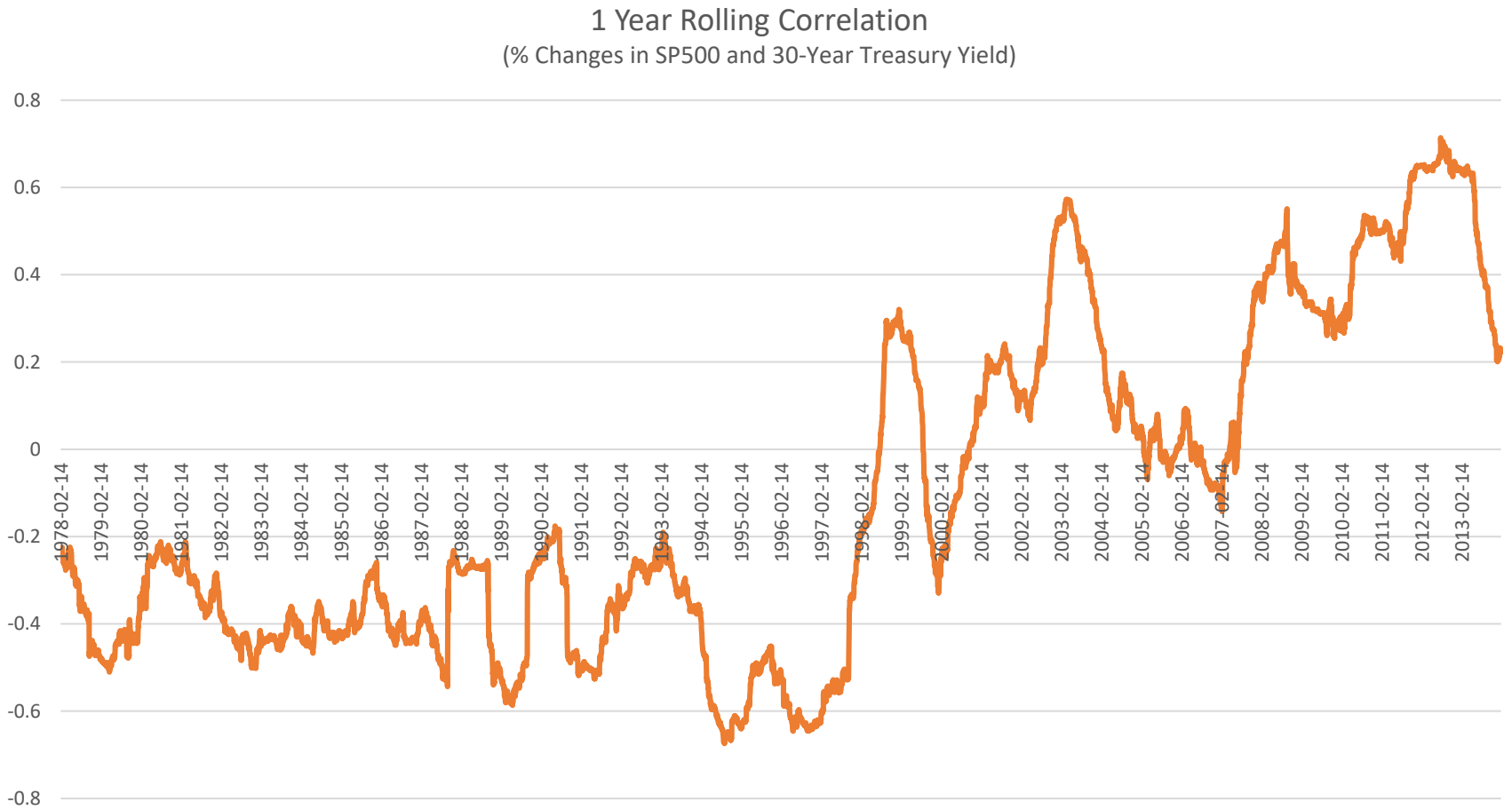
Correlation Matrix

Class	Liquidity	Fixed Income	Real Estate	Global Equity	Absolute Equity	Private Equity
Liquidity	1.00					
Fixed Income	0.30	1.00				
Real Estate	0.25	0.40	1.00			
Global Equity	0.10	0.01	0.40	1.00		
Absolute Return	0.00	0.60	0.30	0.35	1.00	
Private Equity	0.15	-0.10	0.50	0.80	0.10	1.00



Note: Correlation between global equity and fixed income = 0.01

Do not Assume Fixed Correlations over Time



Possible Solution: Dynamic asset allocation in conjunction with regime identification

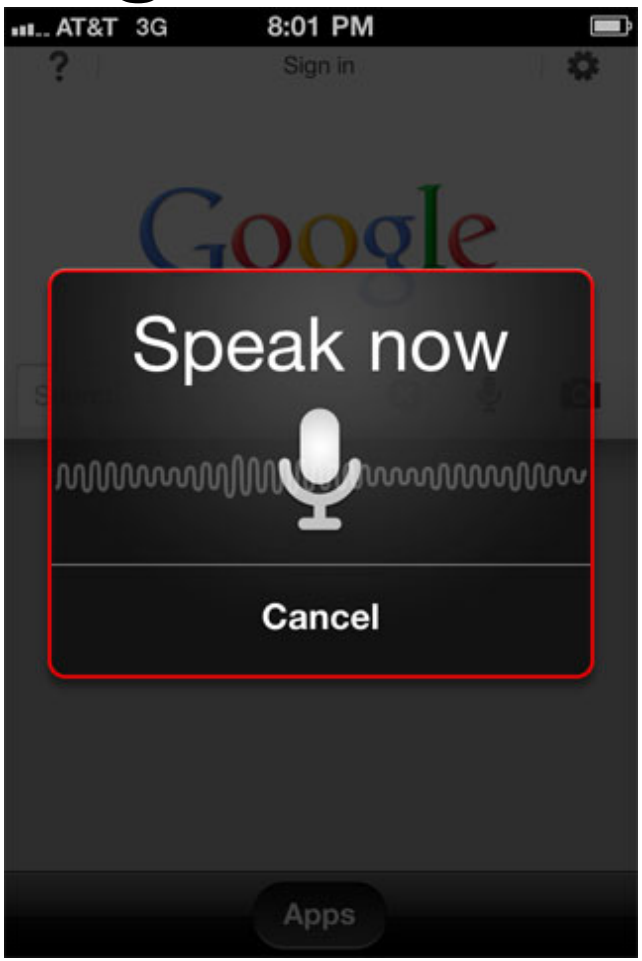
I Want to Ask Someone Out For a Date, And…

- And I need to know how her (or his) mood is today.

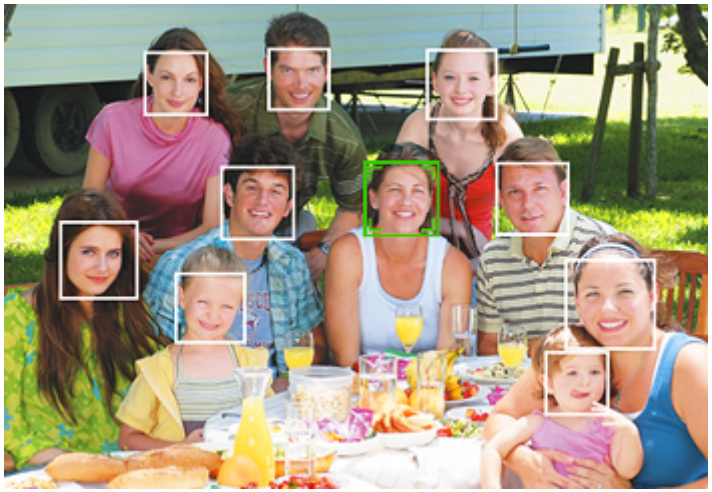
- How do we do this?
  - “Mood” is unobservable
  - Therefore, we observe things such as
    - Facial expression
    - The way she (or he) is dressed
    - The way she (or he) talks
    - …
  - And figure out if she (or he) is in good mood or not based on our “experience”.

- Pattern recognition is an ability built in our brain.

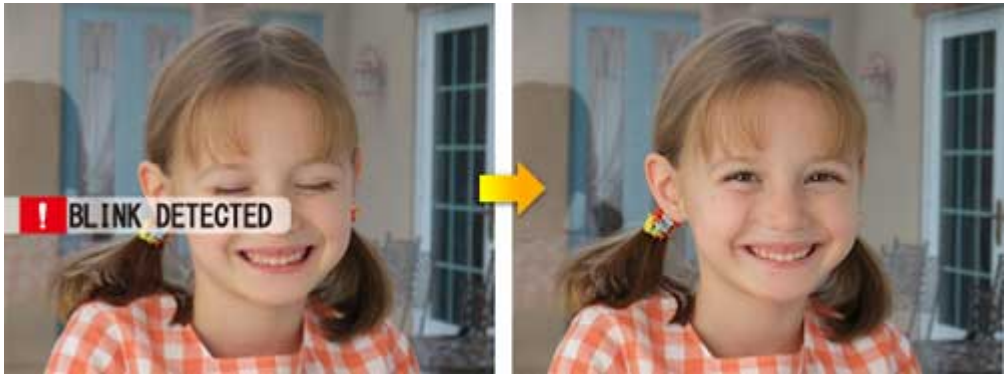
Products/Services Based on Pattern Recognition Technologies



Products/Services Based on Pattern Recognition Technologies



Products/Services Based on Pattern Recognition Technologies



Hidden Markov Model (HMM)

- Has been out there for a while…
- Wide applications in engineering sciences
  - Speech recognition
  - Signal treatment
  - Pattern recognition
- Unsupervised learning
- Only two inputs from the modeler: robust out-of-sample performance
  - Number of states (regimes): “best” number of states can be estimated statistically
  - Shape of observation distribution

A Gamble: Hidden Markov Game

Deck 1

α

1- α

Deck 2

β

1-β

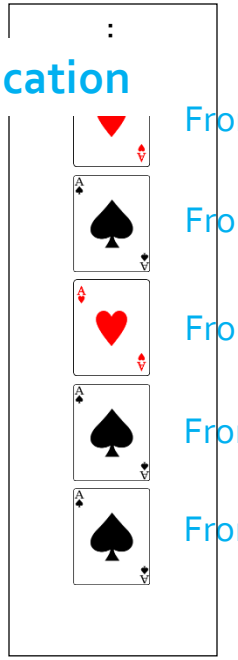
HMM gives us

"Forward-Looking" Regime Identification

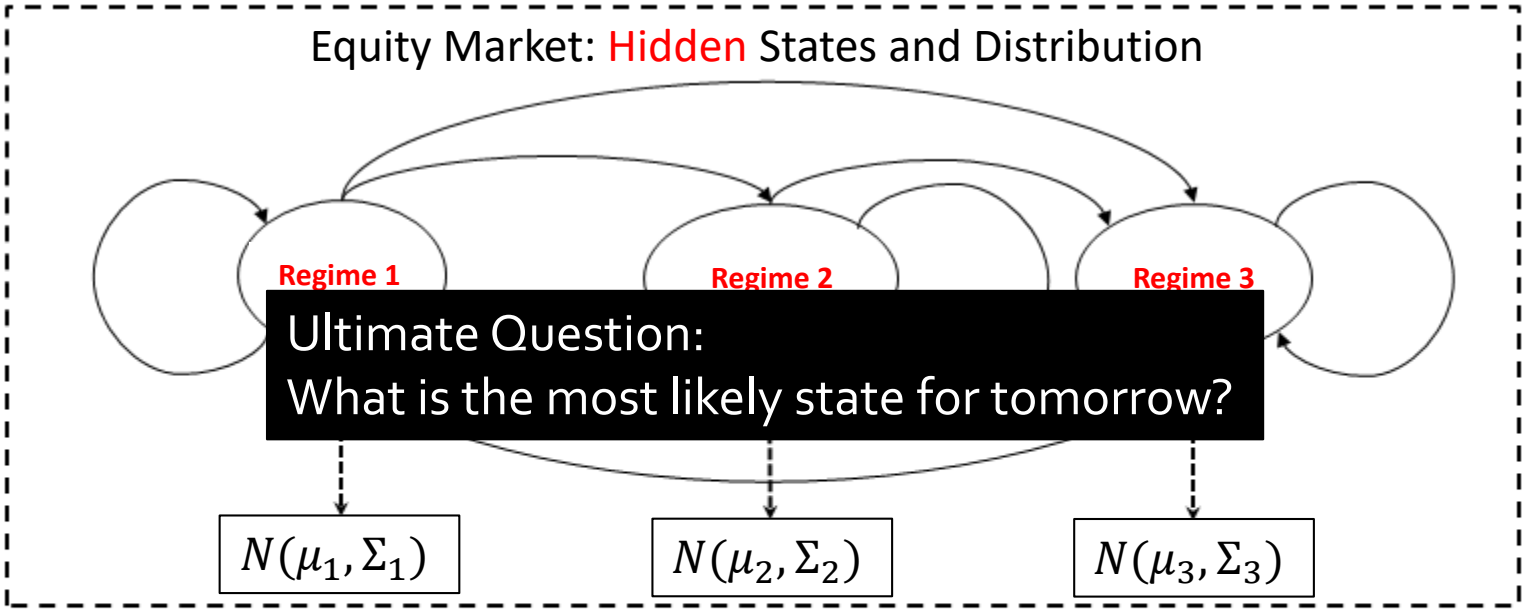
If Deck 1 was chosen at T-1
- Deck 1 is chosen with p chance at T
- Deck 2 is chosen with 1-p chance at T

If Deck 2 was chosen at T-1
- Deck 1 is chosen with q chance at T
- Deck 2 is chosen with 1-q chance at T

Available data:
Sequence of outcomes



Equity Market Regime Identification via HMM

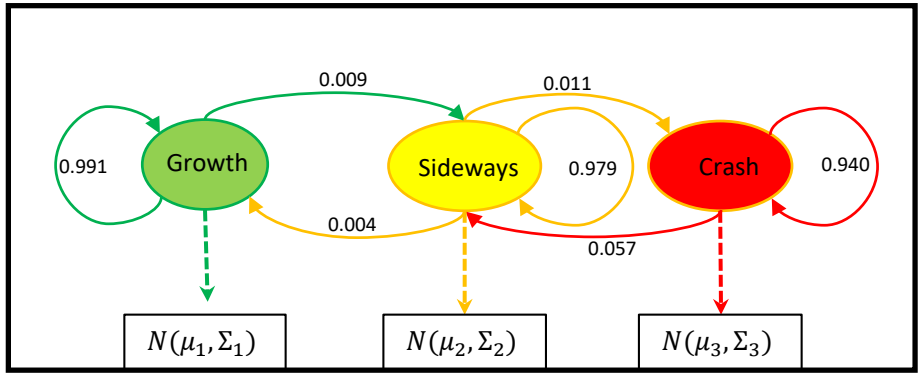


Data

- 25 equity markets covering more than 90% of global market cap
  - North America (2 countries): U.S., and Canada
  - EAFE – Europe (6 countries): Italy, Germany, Spain, Sweden, Swiss, and U.K.
  - EAFE – Asia (4 countries): Australia, Hong Kong, Japan, and Singapore
  - EM (13 countries): Korea, China, India, Russia, South Africa, Brazil, Taiwan, Chile, Indonesia, Malaysia, Mexico, Peru, and Thailand
- Economic intuition: some sectors lead or lag growth and recession periods
  - Input: daily returns of market and sectors (ICB)
  - Test periods: 1973 to 2013
    - 1973 to 1999: training data
    - 2000 to 2013: test data (out-of-sample test)
  - For each “machine”, certain combination of market and sectors are used for input
- Within each state, the returns are assumed to be normally distributed (high-dim).

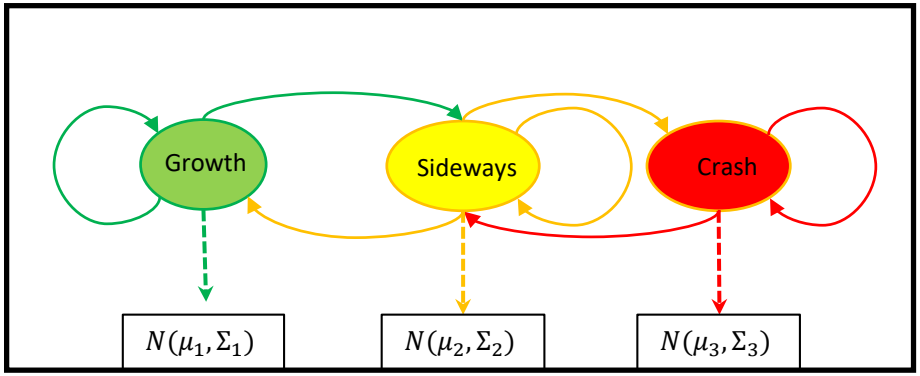
Key Results

- In all countries, # of states (re
  - Regime 1 (growth)
    - high return with low volatility
  - Regime 2 (sideways)
    - moderate return with moderat
  - Regime 3 (crash)
    - negative return with high volati



- Very high recurring probabilities
  - If we were in regime *i* yesterday, today's regime is likely to be *i* as well.
  - Regimes have persistency – regimes do not swift very often.
- Transition probability from regime 1 to 3 or regime 3 to 1 is practically 0.
  - P(Growth at T | Crash at T-1) = 0
  - P(Crash at T | Growth at T-1) = 0

Illustration of Outputs



	Machine 1					Machine 2					Machine 3				
States	G	S	C			G	S	C			G	S	C		
Mkt Avg Ret	15.9%	10.9%	-13.1%			16.4%	9.5%	-15.8%			18.8%	5.6%	-23.5%		
Mkt Vol	10.2%	15.7%	61.1%			10.2%	17.6%	60.2%			10.0%	18.1%	61.9%		
Transition Probability Matrix	G	S	C			G	S	C			G	S	C		
	0.95	0.05	0.00	G		0.96	0.06	0.00	G		0.98	0.03	0.00	G	
	0.05	0.94	0.06	S		0.04	0.93	0.05	S		0.02	0.95	0.06	S	
	0.00	0.01	0.94	C		0.00	0.01	0.95	C		0.00	0.01	0.94	C	

Illustration of Outputs

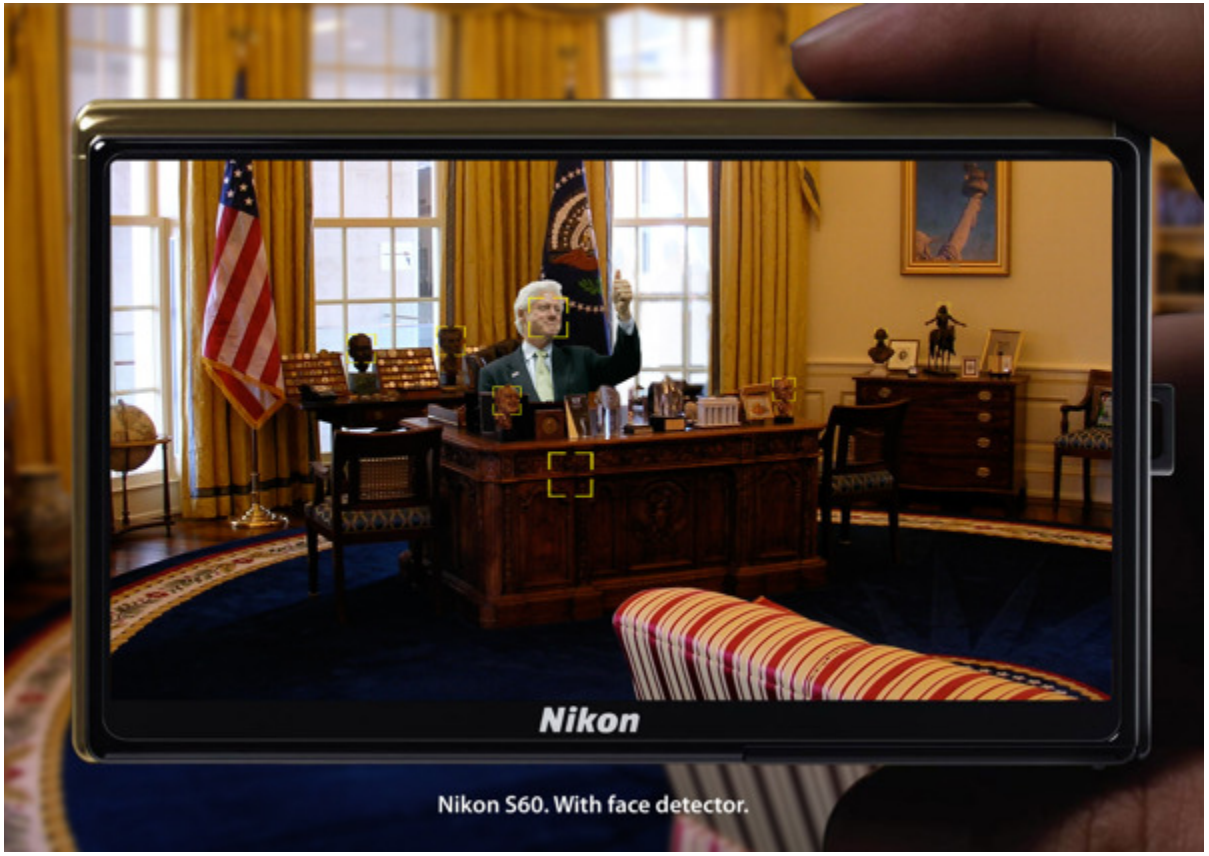
			Machine 1					Machine 2					Machine 3			
Dates	Market Return	Dates	Filt Prob				Dates	Filt Prob				Dates	Filt Prob			
			G	S	C			G	S	C			G	S	C	
01/02/14	-0.9%	01/02/14	90.9%	9.0%	0.1%		01/02/14	95.5%	4.5%	0.0%		01/02/14	95.4%	4.6%	0.0%	
01/03/14	0.0%	01/03/14	95.2%	4.8%	0.0%		01/03/14	97.3%	2.7%	0.0%		01/03/14	97.2%	2.8%	0.0%	
01/06/14	-0.3%	01/06/14	96.5%	3.5%	0.0%		01/06/14	97.2%	2.8%	0.0%		01/06/14	97.0%	3.0%	0.0%	
01/07/14	0.7%	01/07/14	96.6%	3.4%	0.0%		01/07/14	92.4%	7.5%	0.0%		01/07/14	97.7%	2.3%	0.0%	
01/08/14	0.0%	01/08/14	95.1%	4.9%	0.0%		01/08/14	95.9%	4.1%	0.0%		01/08/14	98.4%	1.6%	0.0%	
01/09/14	0.0%	01/09/14	96.2%	3.8%	0.0%		01/09/14	97.5%	2.5%	0.0%		01/09/14	98.2%	1.8%	0.0%	
01/10/14	0.3%	01/10/14	97.2%	2.7%	0.0%		01/10/14	98.0%	2.0%	0.0%		01/10/14	98.6%	1.4%	0.0%	
01/13/14	-1.3%	01/13/14	85.0%	14.8%	0.1%		01/13/14	92.7%	7.3%	0.0%		01/13/14	94.1%	5.9%	0.0%	
01/14/14	1.1%	01/14/14	87.3%	12.6%	0.1%		01/14/14	91.0%	9.0%	0.0%		01/14/14	93.1%	6.8%	0.0%	
01/15/14	0.5%	01/15/14	83.7%	16.2%	0.1%		01/15/14	94.3%	5.7%	0.0%		01/15/14	95.5%	4.5%	0.0%	
01/16/14	-0.1%	01/16/14	92.6%	7.4%	0.0%		01/16/14	96.5%	3.5%	0.0%		01/16/14	97.5%	2.5%	0.0%	
01/17/14	-0.4%	01/17/14	95.0%	4.9%	0.0%		01/17/14	97.3%	2.7%	0.0%		01/17/14	98.0%	2.0%	0.0%	
01/21/14	0.3%	01/21/14	96.5%	3.5%	0.0%		01/21/14	97.9%	2.1%	0.0%		01/21/14	98.3%	1.7%	0.0%	
01/22/14	0.1%	01/22/14	97.1%	2.9%	0.0%		01/22/14	94.3%	5.7%	0.0%		01/22/14	98.6%	1.4%	0.0%	
01/23/14	-0.9%	01/23/14	95.1%	4.9%	0.0%		01/23/14	92.1%	7.9%	0.0%		01/23/14	96.9%	3.1%	0.0%	
01/24/14	-2.2%	01/24/14	49.2%	49.2%	1.6%		01/24/14	12.1%	86.6%	1.2%		01/24/14	5.4%	91.4%	3.3%	
01/27/14	-0.6%	01/27/14	71.2%	28.5%	0.3%		01/27/14	31.7%	67.8%	0.4%		01/27/14	9.5%	88.8%	1.7%	
01/28/14	0.7%	01/28/14	84.9%	15.0%	0.1%		01/28/14	55.8%	44.0%	0.2%		01/28/14	19.8%	79.5%	0.7%	
01/29/14	-1.0%	01/29/14	83.2%	16.7%	0.1%		01/29/14	0.5%	96.4%	3.1%		01/29/14	21.1%	78.3%	0.6%	
01/30/14	1.2%	01/30/14	52.1%	47.4%	0.5%		01/30/14	2.8%	95.1%	2.1%		01/30/14	17.3%	81.8%	0.9%	
01/31/14	-0.6%	01/31/14	51.3%	48.3%	0.4%		01/31/14	16.3%	83.0%	0.7%		01/31/14	30.8%	68.7%	0.5%	
02/03/14	-2.4%	02/03/14	2.6%	91.5%	5.9%		02/03/14	0.6%	96.6%	2.8%		02/03/14	0.3%	96.3%	3.4%	
02/04/14	0.8%	02/04/14	15.9%	82.3%	1.8%		02/04/14	13.1%	86.1%	0.9%		02/04/14	6.5%	92.2%	1.3%	
02/05/14	-0.2%	02/05/14	29.0%	70.4%	0.7%		02/05/14	36.8%	62.8%	0.3%		02/05/14	21.4%	78.1%	0.5%	
02/06/14	1.3%	02/06/14	33.4%	66.0%	0.6%		02/06/14	38.6%	61.0%	0.3%		02/06/14	19.6%	79.8%	0.6%	
02/07/14	1.3%	02/07/14	37.6%	61.8%	0.6%		02/07/14	40.1%	59.5%	0.4%		02/07/14	18.2%	81.1%	0.7%	
02/10/14	0.2%	02/10/14	42.7%	56.9%	0.4%		02/10/14	68.8%	31.1%	0.1%		02/10/14	17.3%	81.8%	0.9%	

Part 5. Product (or Strategy) Design

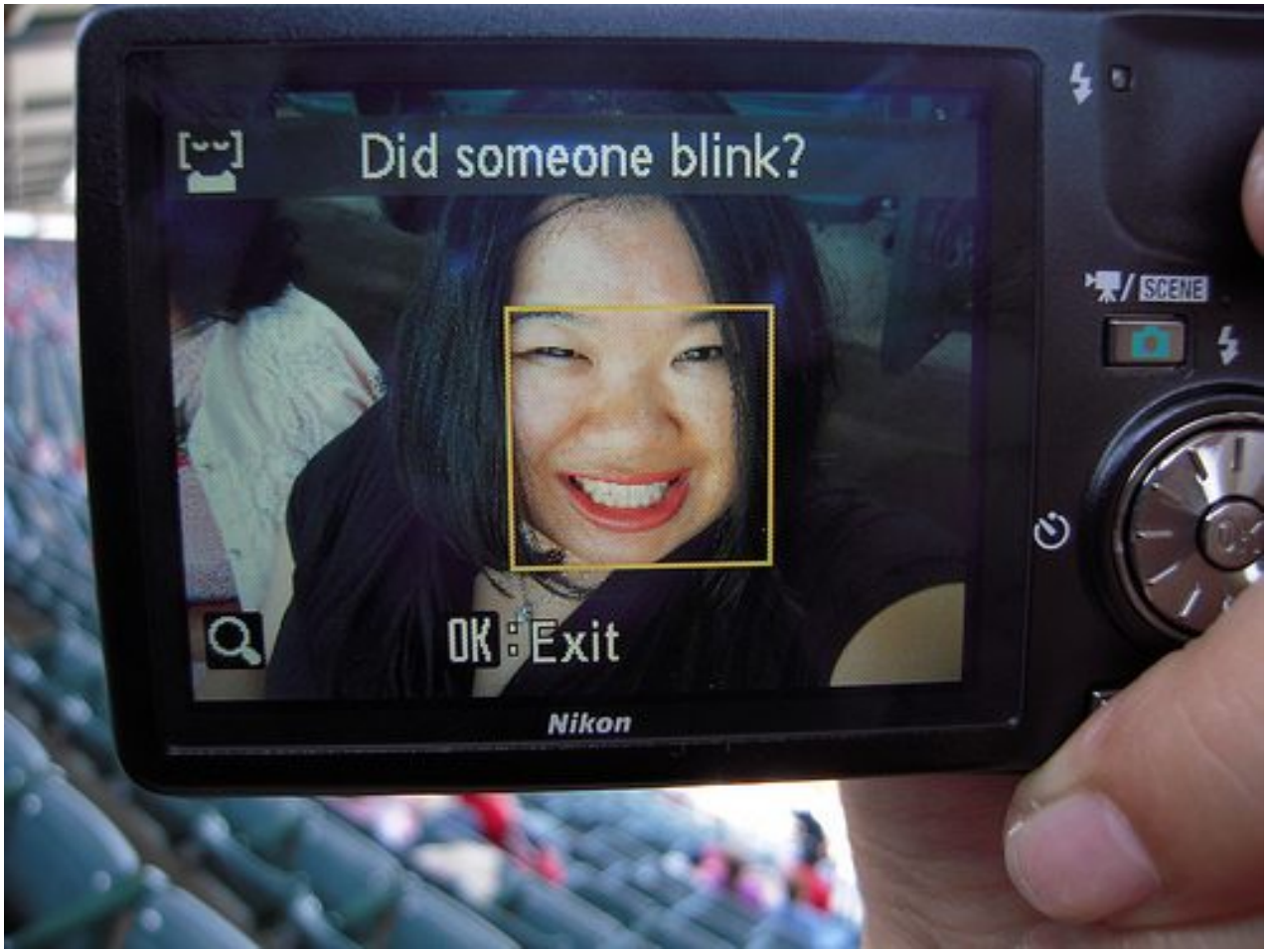
Recall

			Machine 1					Machine 2					Machine 3			
Dates	Market Return	Dates	Filt Prob				Dates	Filt Prob				Dates	Filt Prob			
			G	S	C			G	S	C			G	S	C	
01/02/14	-0.9%	01/02/14	90.9%	9.0%	0.1%		01/02/14	95.5%	4.5%	0.0%		01/02/14	95.4%	4.6%	0.0%	
01/03/14	0.0%	01/03/14	95.2%	4.8%	0.0%		01/03/14	97.3%	2.7%	0.0%		01/03/14	97.2%	2.8%	0.0%	
01/06/14	-0.3%	01/06/14	96.5%	3.5%	0.0%		01/06/14	97.2%	2.8%	0.0%		01/06/14	97.0%	3.0%	0.0%	
01/07/14	0.7%	01/07/14	96.6%	3.4%	0.0%		01/07/14	92.4%	7.5%	0.0%		01/07/14	97.7%	2.3%	0.0%	
01/08/14	0.0%	01/08/14	95.1%	4.9%	0.0%		01/08/14	95.9%	4.1%	0.0%		01/08/14	98.4%	1.6%	0.0%	
01/09/14	0.0%	01/09/14	96.2%	3.8%	0.0%		01/09/14	97.5%	2.5%	0.0%		01/09/14	98.2%	1.8%	0.0%	
01/10/14	0.3%	01/10/14	97.2%	2.7%	0.0%		01/10/14	98.0%	2.0%	0.0%		01/10/14	98.6%	1.4%	0.0%	
01/13/14	-1.3%	01/13/14	85.0%	14.8%	0.1%		01/13/14	92.7%	7.3%	0.0%		01/13/14	94.1%	5.9%	0.0%	
01/14/14	1.1%	01/14/14	87.3%	12.6%	0.1%		01/14/14	91.0%	9.0%	0.0%		01/14/14	93.1%	6.8%	0.0%	
01/15/14	0.5%	01/15/14	83.7%	16.2%	0.1%		01/15/14	94.3%	5.7%	0.0%		01/15/14	95.5%	4.5%	0.0%	
01/16/14	-0.1%	01/16/14	92.6%	7.4%	0.0%		01/16/14	96.5%	3.5%	0.0%		01/16/14	97.5%	2.5%	0.0%	
01/17/14	-0.4%	01/17/14	95.0%	4.9%	0.0%		01/17/14	97.3%	2.7%	0.0%		01/17/14	98.0%	2.0%	0.0%	
01/21/14	0.3%	01/21/14	96.5%	3.5%	0.0%		01/21/14	97.9%	2.1%	0.0%		01/21/14	98.3%	1.7%	0.0%	
01/22/14	0.1%	01/22/14	97.1%	2.9%	0.0%		01/22/14	94.3%	5.7%	0.0%		01/22/14	98.6%	1.4%	0.0%	
01/23/14	-0.9%	01/23/14	95.1%	4.9%	0.0%		01/23/14	92.1%	7.9%	0.0%		01/23/14	96.9%	3.1%	0.0%	
01/24/14	-2.2%	01/24/14	49.2%	49.2%	1.6%		01/24/14	12.1%	86.6%	1.2%		01/24/14	5.4%	91.4%	3.3%	
01/27/14	-0.6%	01/27/14	71.2%	28.5%	0.3%		01/27/14	31.7%	67.8%	0.4%		01/27/14	9.5%	88.8%	1.7%	
01/28/14	0.7%	01/28/14	84.9%	15.0%	0.1%		01/28/14	55.8%	44.0%	0.2%		01/28/14	19.8%	79.5%	0.7%	
01/29/14	-1.0%	01/29/14	83.2%	16.7%	0.1%		01/29/14	0.5%	96.4%	3.1%		01/29/14	21.1%	78.3%	0.6%	
01/30/14	1.2%	01/30/14	52.1%	47.4%	0.5%		01/30/14	2.8%	95.1%	2.1%		01/30/14	17.3%	81.8%	0.9%	
01/31/14	-0.6%	01/31/14	51.3%	48.3%	0.4%		01/31/14	16.3%	83.0%	0.7%		01/31/14	30.8%	68.7%	0.5%	
02/03/14	-2.4%	02/03/14	2.6%	91.5%	5.9%		02/03/14	0.6%	96.6%	2.8%		02/03/14	0.3%	96.3%	3.4%	
02/04/14	0.8%	02/04/14	15.9%	82.3%	1.8%		02/04/14	13.1%	86.1%	0.9%		02/04/14	6.5%	92.2%	1.3%	
02/05/14	-0.2%	02/05/14	29.0%	70.4%	0.7%		02/05/14	36.8%	62.8%	0.3%		02/05/14	21.4%	78.1%	0.5%	
02/06/14	1.3%	02/06/14	33.4%	66.0%	0.6%		02/06/14	38.6%	61.0%	0.3%		02/06/14	19.6%	79.8%	0.6%	
02/07/14	1.3%	02/07/14	37.6%	61.8%	0.6%		02/07/14	40.1%	59.5%	0.4%		02/07/14	18.2%	81.1%	0.7%	
02/10/14	0.2%	02/10/14	42.7%	56.9%	0.4%		02/10/14	68.8%	31.1%	0.1%		02/10/14	17.3%	81.8%	0.9%	

Errors: False Positive vs. False Negative



Errors: False Positive vs. False Negative



Errors: False Positive vs. False Negative

- False positive: market is not in crash regime, but system indicates so
- False negative: market is in crash regime, but system indicates that it is not
- Unfortunately, false positive and false negative errors cannot be reduced simultaneously.

Hypothetical Client and Product Design

- Very conservative
  - It is fine not to participate in market upswing
  - However, they want to avoid sharp crashes (such as 2008)

- Product design
  - Reduce false negative as much as possible
  - Consequently, chance of false positive errors increases

Product Design: Step 1

			Machine 1					Machine 2					Machine 3			
Dates	Market Return	Dates	Filt Prob				Dates	Filt Prob				Dates	Filt Prob			
			G	S	C			G	S	C			G	S	C	
01/02/14	-0.9%	01/02/14	90.9%	9.0%	0.1%		01/02/14	95.5%	4.5%	0.0%		01/02/14	95.4%	4.6%	0.0%	
01/03/14	0.0%	01/03/14	95.2%	4.8%	0.0%		01/03/14	97.3%	2.7%	0.0%		01/03/14	97.2%	2.8%	0.0%	
01/06/14	-0.3%	01/06/14	96.5%	3.5%	0.0%		01/06/14	97.2%	2.8%	0.0%		01/06/14	97.0%	3.0%	0.0%	
01/07/14	0.7%	01/07/14	96.6%	3.4%	0.0%		01/07/14	92.4%	7.5%	0.0%		01/07/14	97.7%	2.3%	0.0%	
01/08/14	0.0%	01/08/14	95.1%	4.9%	0.0%		01/08/14	95.9%	4.1%	0.0%		01/08/14	98.4%	1.6%	0.0%	
01/09/14	0.0%	01/09/14	96.2%	3.8%	0.0%		01/09/14	97.5%	2.5%	0.0%		01/09/14	98.2%	1.8%	0.0%	
01/10/14	0.3%	01/10/14	97.2%	2.7%	0.0%		01/10/14	98.0%	2.0%	0.0%		01/10/14	98.6%	1.4%	0.0%	
01/13/14	-1.3%	01/13/14	85.0%	14.8%	0.1%		01/13/14	92.7%	7.3%	0.0%		01/13/14	94.1%	5.9%	0.0%	
01/14/14	1.1%	01/14/14	87.3%	12.6%	0.1%		01/14/14	91.0%	9.0%	0.0%		01/14/14	93.1%	6.8%	0.0%	
01/15/14	0.5%	01/15/14	83.7%	16.2%	0.1%		01/15/14	94.3%	5.7%	0.0%		01/15/14	95.5%	4.5%	0.0%	
01/16/14	-0.1%	01/16/14	92.6%	7.4%	0.0%		01/16/14	96.5%	3.5%	0.0%		01/16/14	97.5%	2.5%	0.0%	
01/17/14	-0.4%	01/17/14	95.0%	4.9%	0.0%		01/17/14	97.3%	2.7%	0.0%		01/17/14	98.0%	2.0%	0.0%	
01/21/14	0.3%	01/21/14	96.5%	3.5%	0.0%		01/21/14	97.9%	2.1%	0.0%		01/21/14	98.3%	1.7%	0.0%	
01/22/14	0.1%	01/22/14	97.1%	2.9%	0.0%		01/22/14	94.3%	5.7%	0.0%		01/22/14	98.6%	1.4%	0.0%	
01/23/14	-0.9%	01/23/14	95.1%	4.9%	0.0%		01/23/14	92.1%	7.9%	0.0%		01/23/14	96.9%	3.1%	0.0%	
01/24/14	-2.2%	01/24/14	49.2%	49.2%	1.6%		01/24/14	12.1%	86.6%	1.2%		01/24/14	5.4%	91.4%	3.3%	
01/27/14	-0.6%	01/27/14	71.2%	28.5%	0.3%		01/27/14	31.7%	67.8%	0.4%		01/27/14	9.5%	88.8%	1.7%	
01/28/14	0.7%	01/28/14	84.9%	15.0%	0.1%		01/28/14	55.8%	44.0%	0.2%		01/28/14	19.8%	79.5%	0.7%	
01/29/14	-1.0%	01/29/14	83.2%	16.7%	0.1%		01/29/14	0.5%	96.4%	3.1%		01/29/14	21.1%	78.3%	0.6%	
01/30/14	1.2%	01/30/14	52.1%	47.4%	0.5%		01/30/14	2.8%	95.1%	2.1%		01/30/14	17.3%	81.8%	0.9%	
01/31/14	-0.6%	01/31/14	51.3%	48.3%	0.4%		01/31/14	16.3%	83.0%	0.7%		01/31/14	30.8%	68.7%	0.5%	
02/03/14	-2.4%	02/03/14	2.6%	91.5%	5.9%		02/03/14	0.6%	96.6%	2.8%		02/03/14	0.3%	96.3%	3.4%	
02/04/14	0.8%	02/04/14	15.9%	82.3%	1.8%		02/04/14	13.1%	86.1%	0.9%		02/04/14	6.5%	92.2%	1.3%	
02/05/14	-0.2%	02/05/14	29.0%	70.4%	0.7%		02/05/14	36.8%	62.8%	0.3%		02/05/14	21.4%	78.1%	0.5%	
02/06/14	1.3%	02/06/14	33.4%	66.0%	0.6%		02/06/14	38.6%	61.0%	0.3%		02/06/14	19.6%	79.8%	0.6%	
02/07/14	1.3%	02/07/14	37.6%	61.8%	0.6%		02/07/14	40.1%	59.5%	0.4%		02/07/14	18.2%	81.1%	0.7%	
02/10/14	0.2%	02/10/14	42.7%	56.9%	0.4%		02/10/14	68.8%	31.1%	0.1%		02/10/14	17.3%	81.8%	0.9%	

Product Design: Step 2

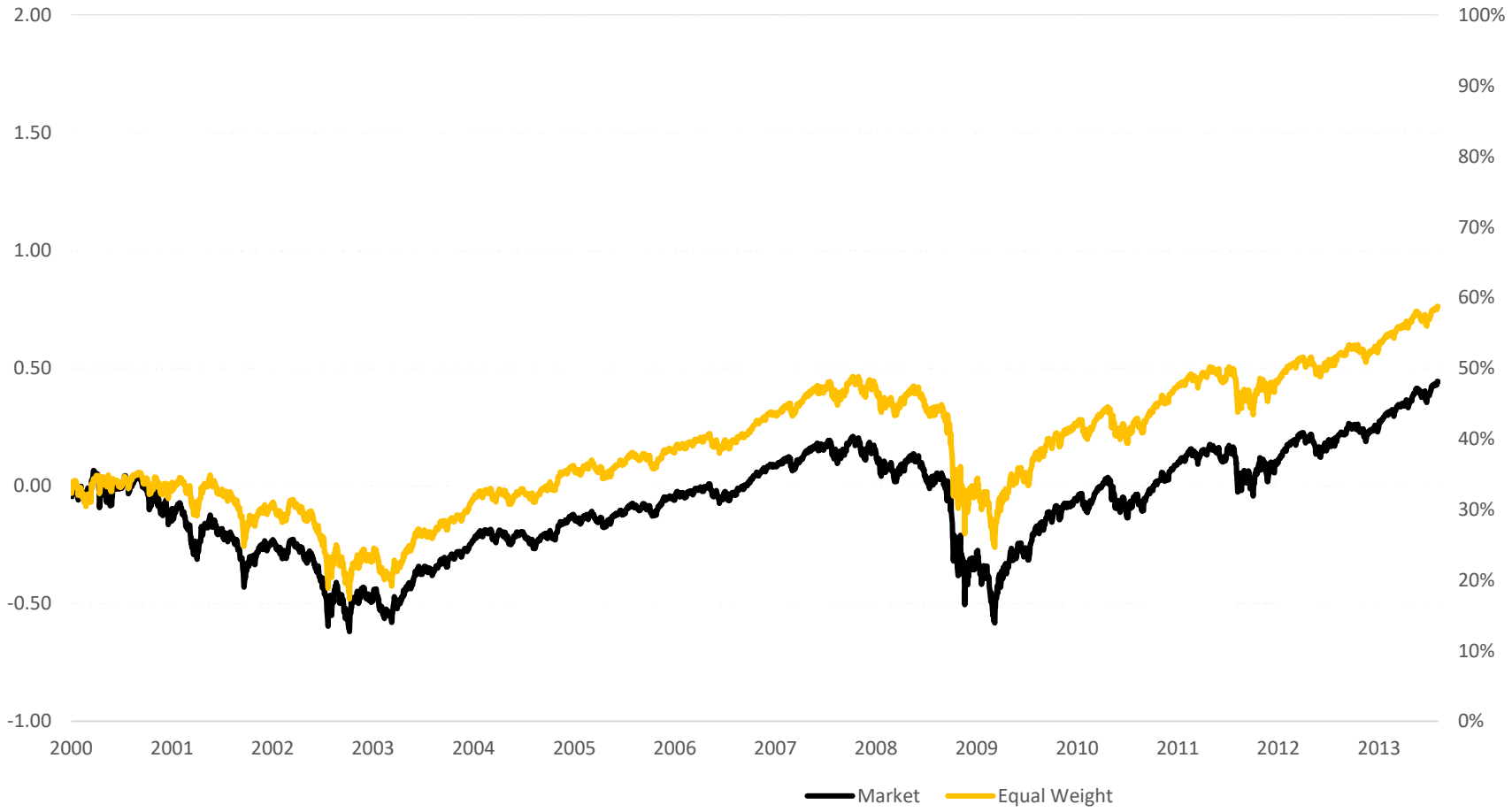
			Machine 1					Machine 2					Machine 3			
Dates	Market Return	Dates	Filt Prob				Dates	Filt Prob				Dates	Filt Prob			
			G	S	C			G	S	C			G	S	C	
01/02/14	-0.9%	01/02/14	90.9%	9.0%	0.1%	G	01/02/14	95.5%	4.5%	0.0%	G	01/02/14	95.4%	4.6%	0.0%	G
01/03/14	0.0%	01/03/14	95.2%	4.8%	0.0%	G	01/03/14	97.3%	2.7%	0.0%	G	01/03/14	97.2%	2.8%	0.0%	G
01/06/14	-0.3%	01/06/14	96.5%	3.5%	0.0%	G	01/06/14	97.2%	2.8%	0.0%	G	01/06/14	97.0%	3.0%	0.0%	G
01/07/14	0.7%	01/07/14	96.6%	3.4%	0.0%	G	01/07/14	92.4%	7.5%	0.0%	G	01/07/14	97.7%	2.3%	0.0%	G
01/08/14	0.0%	01/08/14	95.1%	4.9%	0.0%	G	01/08/14	95.9%	4.1%	0.0%	G	01/08/14	98.4%	1.6%	0.0%	G
01/09/14	0.0%	01/09/14	96.2%	3.8%	0.0%	G	01/09/14	97.5%	2.5%	0.0%	G	01/09/14	98.2%	1.8%	0.0%	G
01/10/14	0.3%	01/10/14	97.2%	2.7%	0.0%	G	01/10/14	98.0%	2.0%	0.0%	G	01/10/14	98.6%	1.4%	0.0%	G
01/13/14	-1.3%	01/13/14	85.0%	14.8%	0.1%	G	01/13/14	92.7%	7.3%	0.0%	G	01/13/14	94.1%	5.9%	0.0%	G
01/14/14	1.1%	01/14/14	87.3%	12.6%	0.1%	G	01/14/14	91.0%	9.0%	0.0%	G	01/14/14	93.1%	6.8%	0.0%	G
01/15/14	0.5%	01/15/14	83.7%	16.2%	0.1%	G	01/15/14	94.3%	5.7%	0.0%	G	01/15/14	95.5%	4.5%	0.0%	G
01/16/14	-0.1%	01/16/14	92.6%	7.4%	0.0%	G	01/16/14	96.5%	3.5%	0.0%	G	01/16/14	97.5%	2.5%	0.0%	G
01/17/14	-0.4%	01/17/14	95.0%	4.9%	0.0%	G	01/17/14	97.3%	2.7%	0.0%	G	01/17/14	98.0%	2.0%	0.0%	G
01/21/14	0.3%	01/21/14	96.5%	3.5%	0.0%	G	01/21/14	97.9%	2.1%	0.0%	G	01/21/14	98.3%	1.7%	0.0%	G
01/22/14	0.1%	01/22/14	97.1%	2.9%	0.0%	G	01/22/14	94.3%	5.7%	0.0%	G	01/22/14	98.6%	1.4%	0.0%	G
01/23/14	-0.9%	01/23/14	95.1%	4.9%	0.0%	G	01/23/14	92.1%	7.9%	0.0%	G	01/23/14	96.9%	3.1%	0.0%	G
01/24/14	-2.2%	01/24/14	49.2%	49.2%	1.6%	G	01/24/14	12.1%	86.6%	1.2%	S	01/24/14	5.4%	91.4%	3.3%	S
01/27/14	-0.6%	01/27/14	71.2%	28.5%	0.3%	G	01/27/14	31.7%	67.8%	0.4%	S	01/27/14	9.5%	88.8%	1.7%	S
01/28/14	0.7%	01/28/14	84.9%	15.0%	0.1%	G	01/28/14	55.8%	44.0%	0.2%	G	01/28/14	19.8%	79.5%	0.7%	S
01/29/14	-1.0%	01/29/14	83.2%	16.7%	0.1%	G	01/29/14	0.5%	96.4%	3.1%	S	01/29/14	21.1%	78.3%	0.6%	S
01/30/14	1.2%	01/30/14	52.1%	47.4%	0.5%	G	01/30/14	2.8%	95.1%	2.1%	S	01/30/14	17.3%	81.8%	0.9%	S
01/31/14	-0.6%	01/31/14	51.3%	48.3%	0.4%	G	01/31/14	16.3%	83.0%	0.7%	S	01/31/14	30.8%	68.7%	0.5%	S
02/03/14	-2.4%	02/03/14	2.6%	91.5%	5.9%	S	02/03/14	0.6%	96.6%	2.8%	S	02/03/14	0.3%	96.3%	3.4%	S
02/04/14	0.8%	02/04/14	15.9%	82.3%	1.8%	S	02/04/14	13.1%	86.1%	0.9%	S	02/04/14	6.5%	92.2%	1.3%	S
02/05/14	-0.2%	02/05/14	29.0%	70.4%	0.7%	S	02/05/14	36.8%	62.8%	0.3%	S	02/05/14	21.4%	78.1%	0.5%	S
02/06/14	1.3%	02/06/14	33.4%	66.0%	0.6%	S	02/06/14	38.6%	61.0%	0.3%	S	02/06/14	19.6%	79.8%	0.6%	S
02/07/14	1.3%	02/07/14	37.6%	61.8%	0.6%	S	02/07/14	40.1%	59.5%	0.4%	S	02/07/14	18.2%	81.1%	0.7%	S
02/10/14	0.2%	02/10/14	42.7%	56.9%	0.4%	S	02/10/14	68.8%	31.1%	0.1%	G	02/10/14	17.3%	81.8%	0.9%	S

Product Design: Step 3

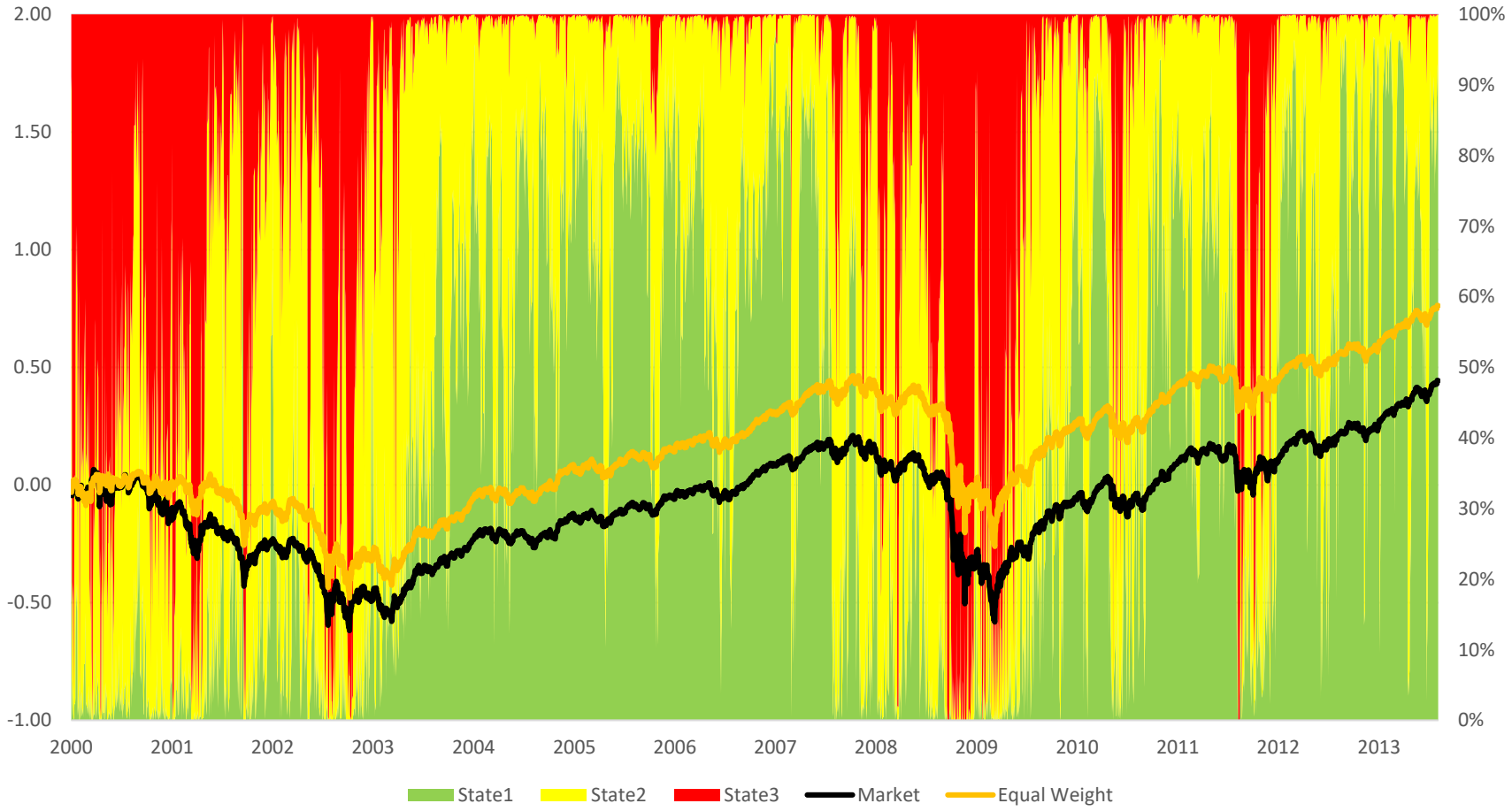
			Machine 1					Machine 2					Machine 3			
Dates	Market Return	Dates	Filt Prob				Dates	Filt Prob				Dates	Filt Prob			
			G	S	C			G	S	C			G	S	C	
01/02/14	-0.9%	01/02/14	90.9%	9.0%	0.1%	G	01/02/14	95.5%	4.5%	0.0%	G	01/02/14	95.4%	4.6%	0.0%	G
01/03/14	0.0%	01/03/14	95.2%	4.8%	0.0%	G	01/03/14	97.3%	2.7%	0.0%	G	01/03/14	97.2%	2.8%	0.0%	G
01/06/14	-0.3%	01/06/14	96.5%	3.5%	0.0%	G	01/06/14	97.2%	2.8%	0.0%	G	01/06/14	97.0%	3.0%	0.0%	G
01/07/14	0.7%	01/07/14	96.6%	3.4%	0.0%	G	01/07/14	92.4%	7.5%	0.0%	G	01/07/14	97.7%	2.3%	0.0%	G
01/08/14	0.0%	01/08/14	95.1%	4.9%	0.0%	G	01/08/14	95.9%	4.1%	0.0%	G	01/08/14	98.4%	1.6%	0.0%	G
01/09/14	0.0%	01/09/14	96.2%	3.8%	0.0%	G	01/09/14	97.5%	2.5%	0.0%	G	01/09/14	98.2%	1.8%	0.0%	G
01/10/14	0.3%	01/10/14	97.2%	2.7%	0.0%	G	01/10/14	98.0%	2.0%	0.0%	G	01/10/14	98.6%	1.4%	0.0%	G
01/13/14	-1.3%	01/13/14	85.0%	14.8%	0.1%	G	01/13/14	92.7%	7.3%	0.0%	G	01/13/14	94.1%	5.9%	0.0%	G
01/14/14	1.1%	01/14/14	87.3%	12.6%	0.1%	G	01/14/14	91.0%	9.0%	0.0%	G	01/14/14	93.1%	6.8%	0.0%	G
01/15/14	0.5%	01/15/14	83.7%	16.2%	0.1%	G	01/15/14	94.3%	5.7%	0.0%	G	01/15/14	95.5%	4.5%	0.0%	G
01/16/14	-0.1%	01/16/14	92.6%	7.4%	0.0%	G	01/16/14	96.5%	3.5%	0.0%	G	01/16/14	97.5%	2.5%	0.0%	G
01/17/14	-0.4%	01/17/14	95.0%	4.9%	0.0%	G	01/17/14	97.3%	2.7%	0.0%	G	01/17/14	98.0%	2.0%	0.0%	G
01/21/14	0.3%	01/21/14	96.5%	3.5%	0.0%	G	01/21/14	97.9%	2.1%	0.0%	G	01/21/14	98.3%	1.7%	0.0%	G
01/22/14	0.1%	01/22/14	97.1%	2.9%	0.0%	G	01/22/14	94.3%	5.7%	0.0%	G	01/22/14	98.6%	1.4%	0.0%	G
01/23/14	-0.9%	01/23/14	95.1%	4.9%	0.0%	G	01/23/14	92.1%	7.9%	0.0%	G	01/23/14	96.9%	3.1%	0.0%	G
01/24/14	-2.2%	01/24/14	49.2%	49.2%	1.6%	G	01/24/14	12.1%	86.6%	1.2%	S	01/24/14	5.4%	91.4%	3.3%	S
01/27/14	-0.6%	01/27/14	71.2%	28.5%	0.3%	G	01/27/14	31.7%	67.8%	0.4%	S	01/27/14	9.5%	88.8%	1.7%	S
01/28/14	0.7%	01/28/14	84.9%	15.0%	0.1%	G	01/28/14	55.8%	44.0%	0.2%	G	01/28/14	19.8%	79.5%	0.7%	S
01/29/14	-1.0%	01/29/14	83.2%	16.7%	0.1%	G	01/29/14	0.5%	96.4%	3.1%	S	01/29/14	21.1%	78.3%	0.6%	S
01/30/14	1.2%	01/30/14	52.1%	47.4%	0.5%	G	01/30/14	2.8%	95.1%	2.1%	S	01/30/14	17.3%	81.8%	0.9%	S
01/31/14	-0.6%	01/31/14	51.3%	48.3%	0.4%	G	01/31/14	16.3%	83.0%	0.7%	S	01/31/14	30.8%	68.7%	0.5%	S
02/03/14	-2.4%	02/03/14	2.6%	91.5%	5.9%	S	02/03/14	0.6%	96.6%	2.8%	S	02/03/14	0.3%	96.3%	3.4%	S
02/04/14	0.8%	02/04/14	15.9%	82.3%	1.8%	S	02/04/14	13.1%	86.1%	0.9%	S	02/04/14	6.5%	92.2%	1.3%	S
02/05/14	-0.2%	02/05/14	29.0%	70.4%	0.7%	S	02/05/14	36.8%	62.8%	0.3%	S	02/05/14	21.4%	78.1%	0.5%	S
02/06/14	1.3%	02/06/14	33.4%	66.0%	0.6%	S	02/06/14	38.6%	61.0%	0.3%	S	02/06/14	19.6%	79.8%	0.6%	S
02/07/14	1.3%	02/07/14	37.6%	61.8%	0.6%	S	02/07/14	40.1%	59.5%	0.4%	S	02/07/14	18.2%	81.1%	0.7%	S
02/10/14	0.2%	02/10/14	42.7%	56.9%	0.4%	S	02/10/14	68.8%	31.1%	0.1%	G	02/10/14	17.3%	81.8%	0.9%	S

(Out-of-Sample) Backtest Results for US Market (2000 to 2013)

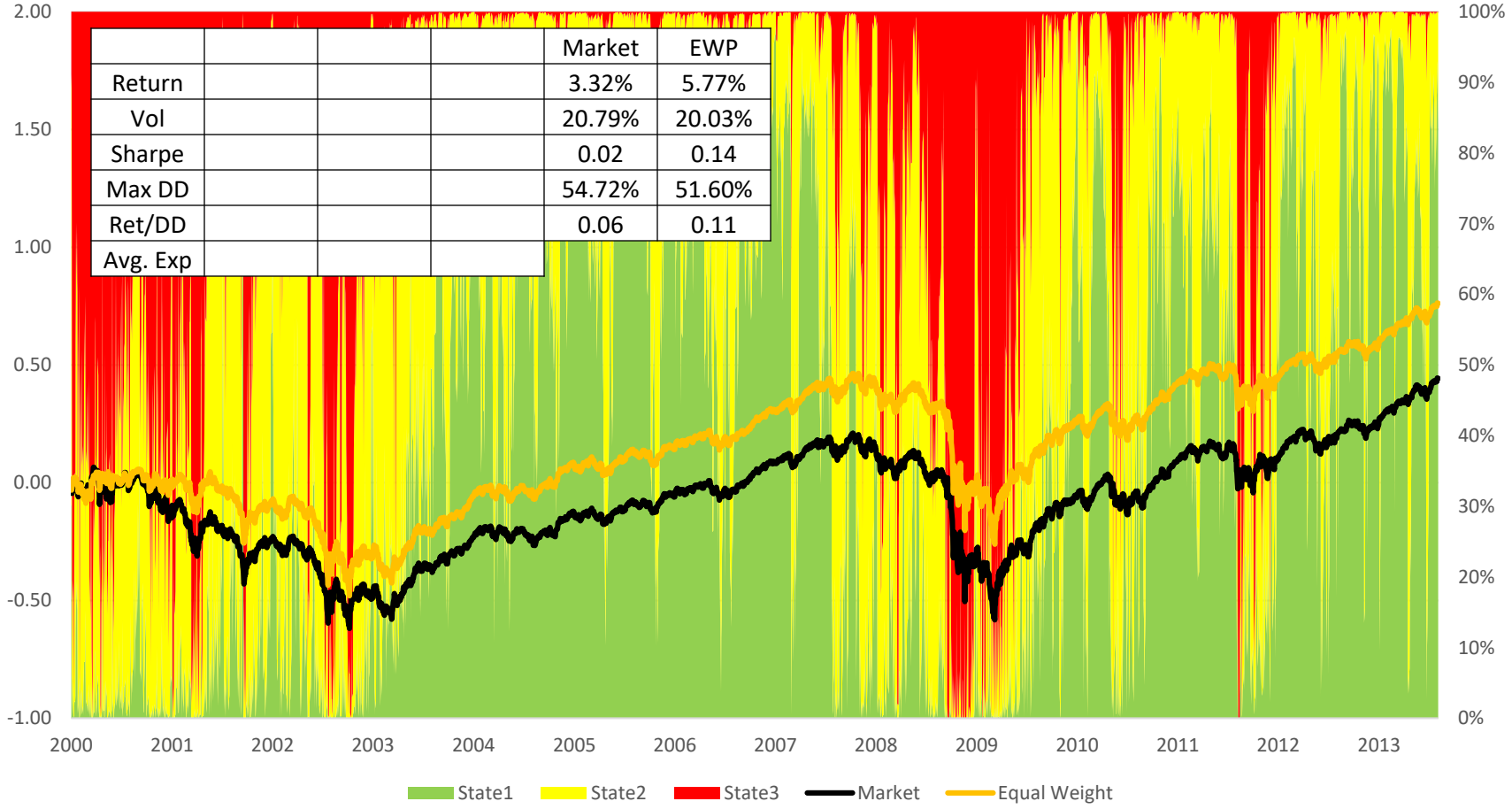
(Out-of-Sample) Backtest Results for US Market (2000 to 2013)



(Out-of-Sample) Backtest Results for US Market (2000 to 2013)

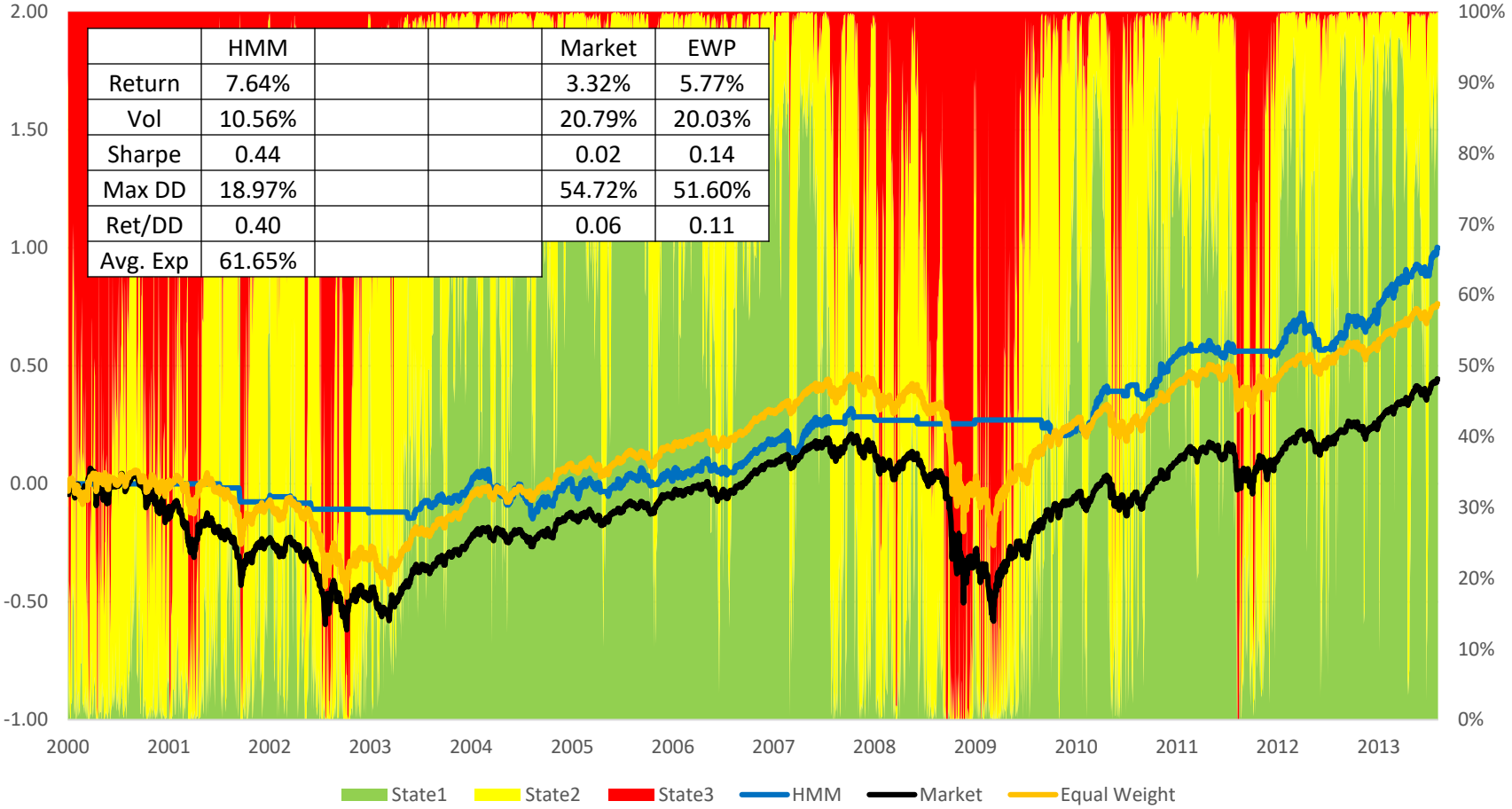


(Out-of-Sample) Backtest Results for US Market (2000 to 2013)



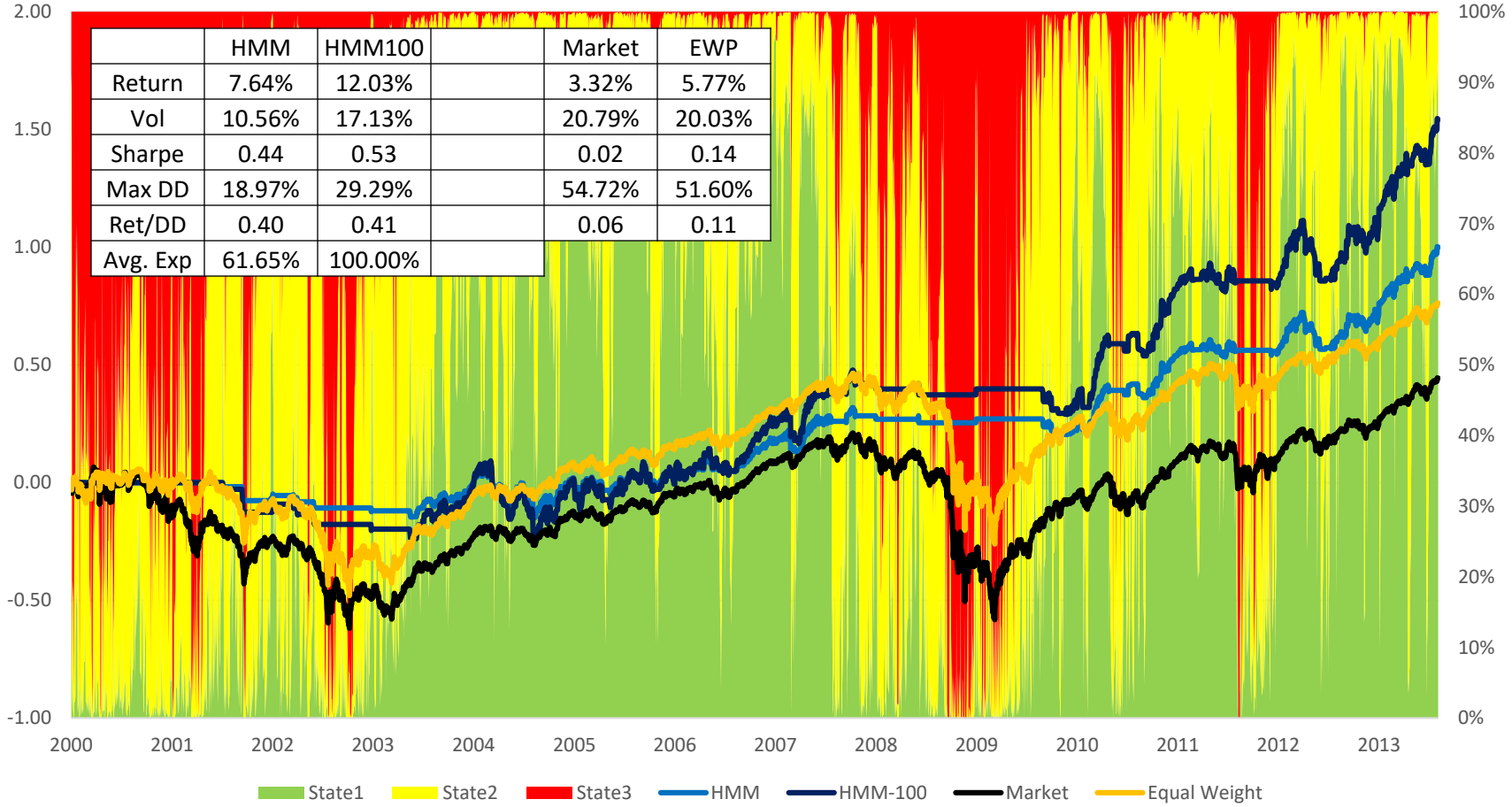
				Market	EWP
Return				3.32%	5.77%
Vol				20.79%	20.03%
Sharpe				0.02	0.14
Max DD				54.72%	51.60%
Ret/DD				0.06	0.11
Avg. Exp					

(Out-of-Sample) Backtest Results for US Market (2000 to 2013)



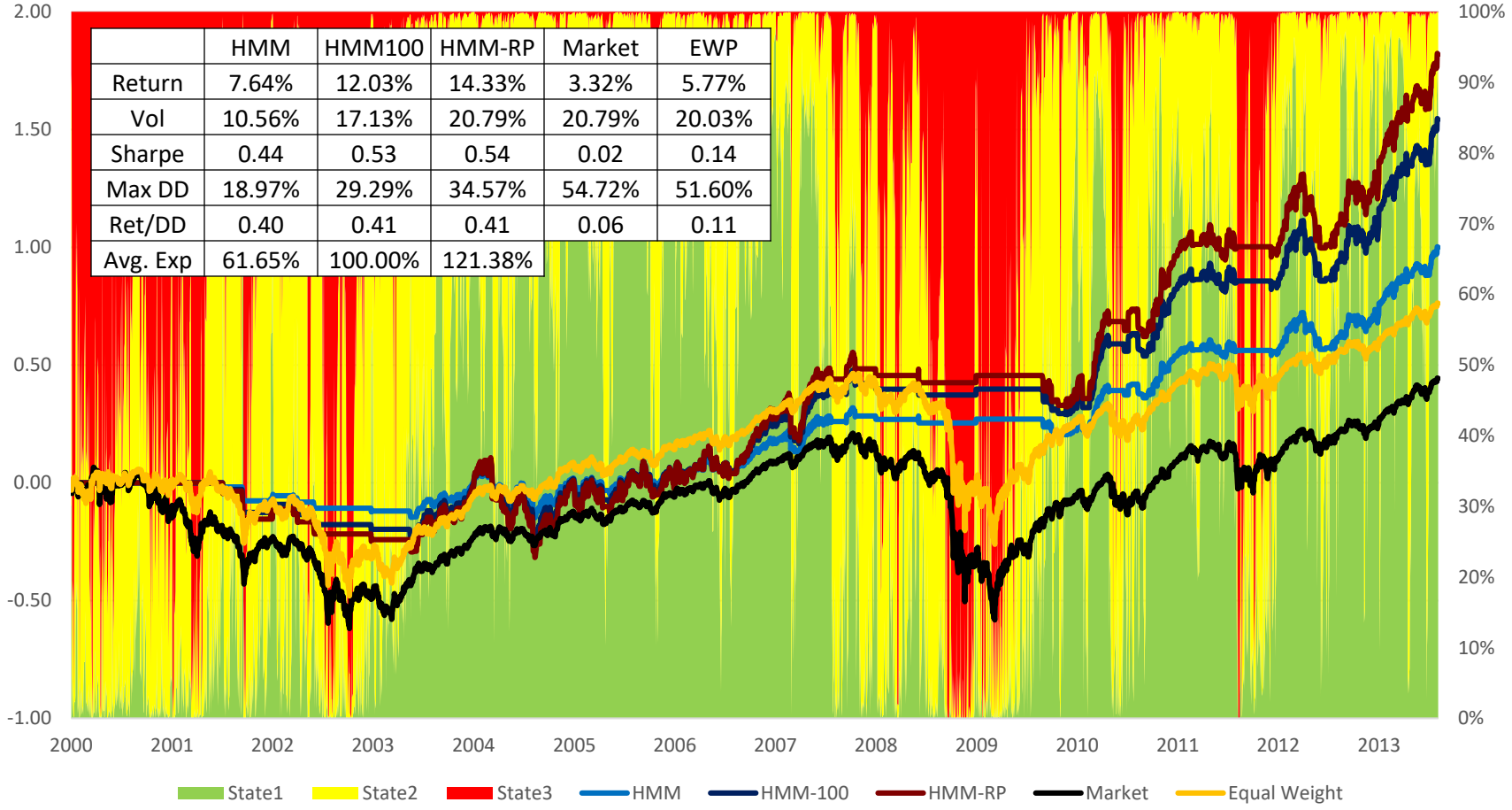
(Out-of-Sample) Backtest Results for US Market (2000 to 2013)

	HMM	HMM100		Market	EWP
Return	7.64%	12.03%		3.32%	5.77%
Vol	10.56%	17.13%		20.79%	20.03%
Sharpe	0.44	0.53		0.02	0.14
Max DD	18.97%	29.29%		54.72%	51.60%
Ret/DD	0.40	0.41		0.06	0.11
Avg. Exp	61.65%	100.00%			



(Out-of-Sample) Backtest Results for US Market (2000 to 2013)

	HMM	HMM100	HMM-RP	Market	EWP
Return	7.64%	12.03%	14.33%	3.32%	5.77%
Vol	10.56%	17.13%	20.79%	20.79%	20.03%
Sharpe	0.44	0.53	0.54	0.02	0.14
Max DD	18.97%	29.29%	34.57%	54.72%	51.60%
Ret/DD	0.40	0.41	0.41	0.06	0.11
Avg. Exp	61.65%	100.00%	121.38%		



Enabling Financial Planning for All Korean Citizens

금융 기술을 통한 사회 보장 강화

https://veranostech.com:5002

Finance vs. Financial Engineering

- Physics vs. Mechanical engineering
  - Physics: 도메인 지식 자체에 대한 연구
  - Mechanical engineering: 도메인 지식을 활용한 공학

- Finance vs. Financial engineering
  - Finance: 금융 자체에 대한 연구 – 경제학 기반
  - Financial engineering: 금융 시장에서 필요한 다양한 기술적, 공학적 이슈에 대한 연구 – 산업공학 기반

진로

- 보험사, 증권사, 투자신탁회사, 자산운용사, 헤지펀드
- 중앙은행, 금융공기업
- 신용평가사, 헤지펀드
- 대학교수