

A vibrant underwater scene from the movie Finding Nemo. In the center, Nemo, the young clownfish, swims towards the viewer. To his left, Marlin, his father, follows him. Above them, Dory, the forgetful blue tang, swims with a yellow triangular object. To the right, Mr. Ray, the seahorse, and his small offspring are visible. In the background, a large pink starfish and a blue tang are swimming away. A red sea slug with a small crab on its back is near the bottom left. A small crab is also on the ocean floor. The water is a clear, light blue.

Funding NIMo

Net Interest Margin Optimization

jss

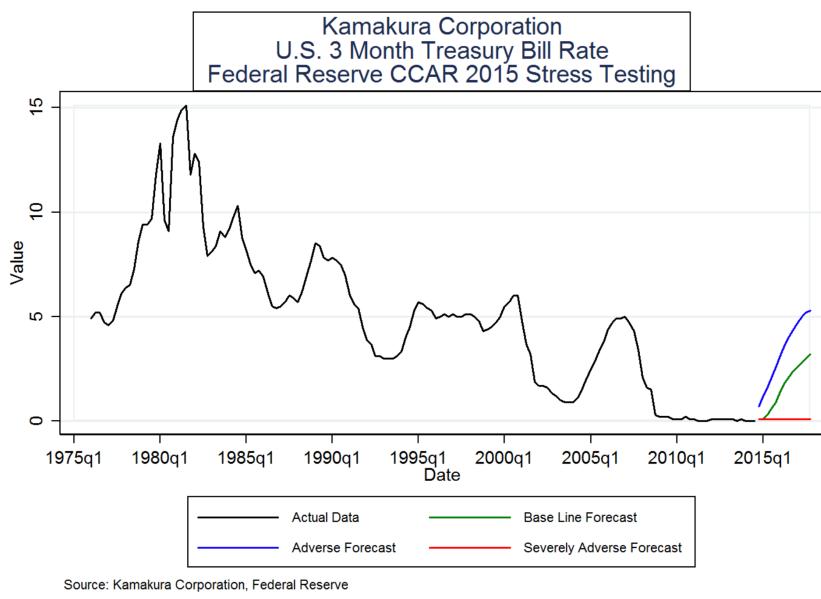
Update

Jul-2015

Main Idea

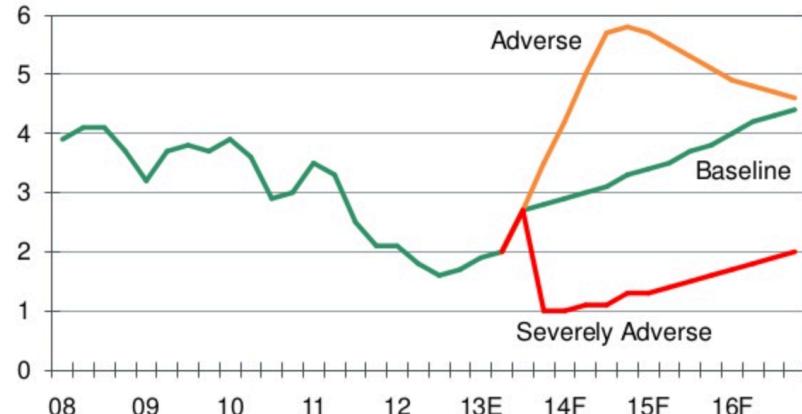
The Board of Governors of the Federal Reserve System, via the Comprehensive Capital Analysis and Review (CCAR) program, has opened up a \$100+ Bn annual market in optimizing the Net Interest Margins at banks with substantial balance sheets in expected case scenarios.

CCAR



Adverse Driven by a Surge in LT Treasury Rates...

10-yr Treasury bond rate, %



Sources: Federal Reserve, Moody's Analytics

Moody's
ANALYTICS

9

Why is NIM Forecasting important?

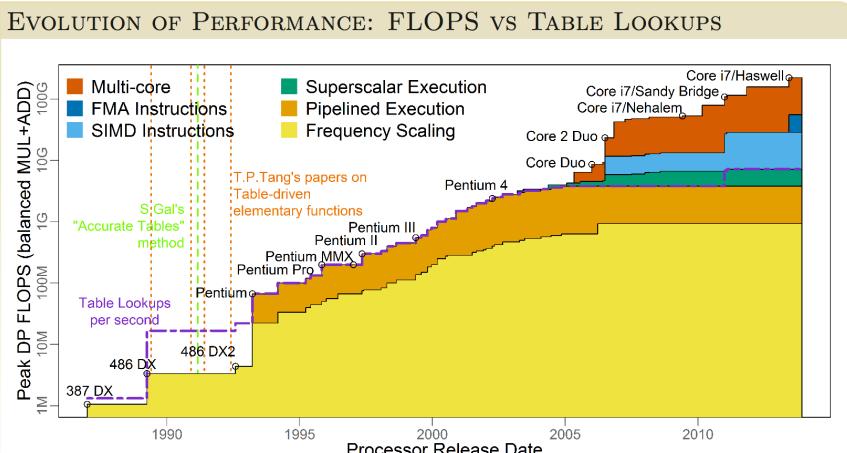
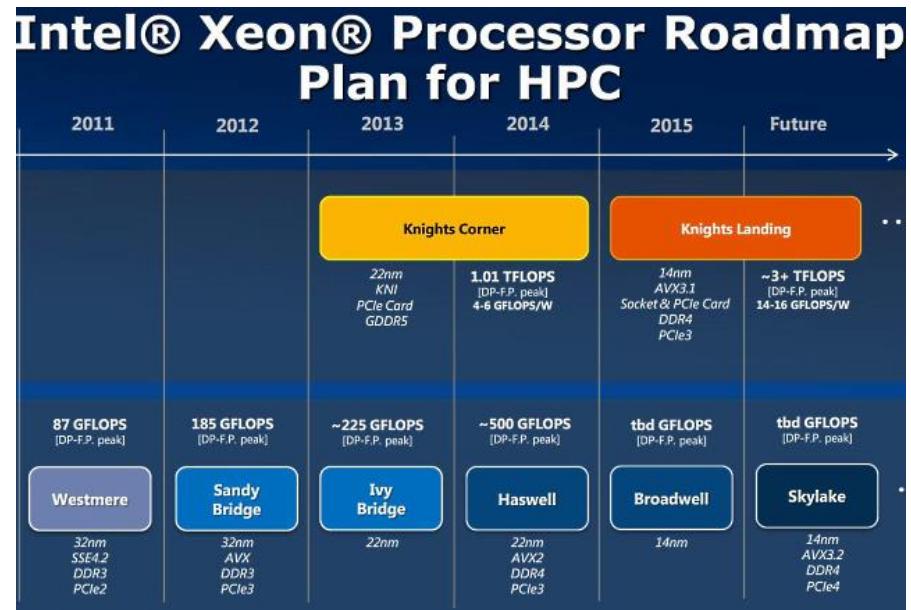
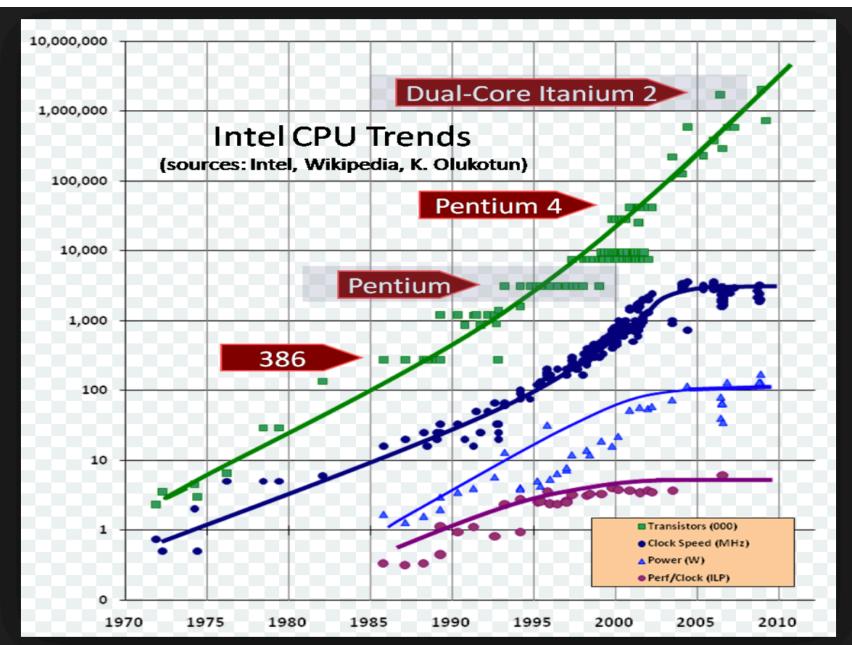
- A bp of NIM ~\$180mm of annual revenue for large Balance Sheet Bank.
- +0.2% in automated Capital Allocation efficiency at 300 bps NIM is 0.6bps.
- **\$100+mm USD annual revenue (in perpetuity), otherwise foregone.**

1. All Large US Banks are running CCAR
2. CCAR cleaning up Balance Sheet data (positions, indicatives, market data)
3. Idea: Make CCAR sunk costs produce revenue by simulating the full Balance Sheet in the expected case to direct capital allocation.

References:

- [Finding Nemo](#), Disney/Pixar
- [van Deventer, Kamakura Corporation, Dec 2014](#)
- [FRB, Comprehensive Capital Analysis and Review](#)
- [Assessing the Fed's CCAR Scenarios, Moody's](#)

2015 Inflection Point – “Free” FP



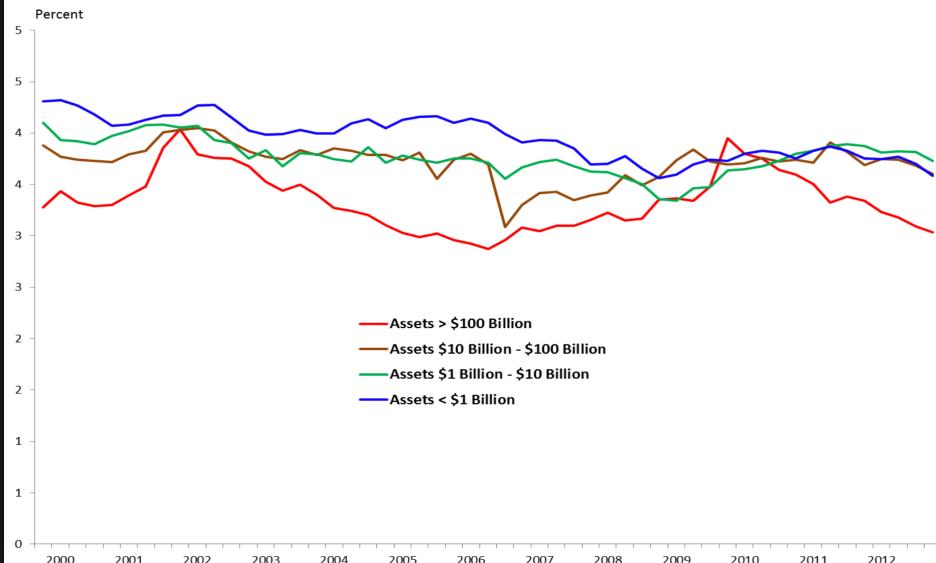
1. FLOPS execute every 7-8 picoseconds – in 2015
2. Need Vector code issue to get the “free” FLOPS – sporadically done in Wall Street shops.
3. Still some wave to ride - Moore’s Law continues to increase FLOPS Supply through ~ 2020
4. Idea: Use “free” FLOPS to make CCAR Full Balance sheet simulation faster on smaller core footprint.

References:

- [Dukhan, Hot Chips 2013.](#)
- [Intel Roadmap](#)
- [Colwell, Hot Chips, 2013, The Chip Design Game at the End of Moore’s Law.](#)

NIM Optimization

Quarterly Net Interest Margin (NIM)



NIM = Avg. Interest Assets - Avg. Interest Liabilities

Classical Nonlinear Optimization Problem:

Find x in R^n , the allocation of capital to

Maximize:

$$f(x) - \text{The Firm NIM}$$

Subject to:

$$g_i(x) \leq 0$$

$$h_j(x) = 0$$

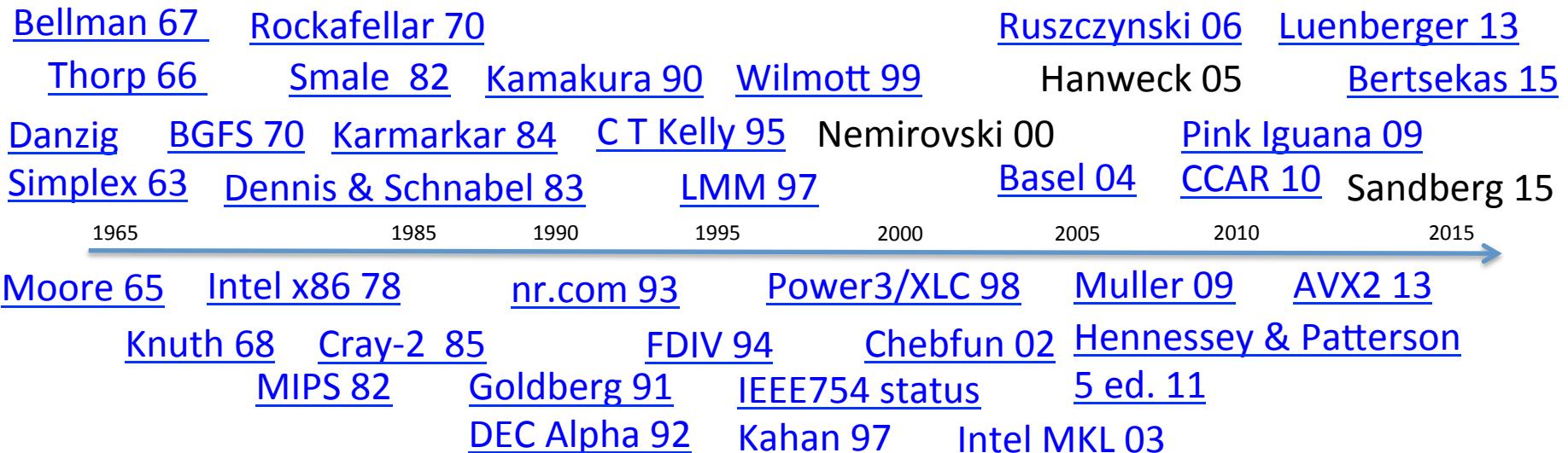


1. Wide NIM dispersion ~ 100 bps 2005
2. NIM Now at 30 Year Low
3. Idea: Numerically Optimize NIM/NIR/Full Bank Balance Sheet/Asset & Liability Security level – stop steering a rocket with a joystick.
4. Idea: Automate Bank NIM Growth +30 bps per annum.
5. Idea: Numerically optimize NIM using all Target Market's Assets (e.g., start with US Fed data).

References:

- [FDIC, Remarks by Gruenberg 1Q2013](#)
- [FRED, NIM for US Banks](#)
- G. Hanweck, https://www.fdic.gov/bank/analytical/working/wp2005/WP2005_2.pdf

NIMo Timeline



Trifecta:

1. CCAR – Full Firm Balance Sheet simulation
2. Free FLOPs
3. Numerical Optimization

1. There is accurate clean Accrual Portfolio data now.
2. In the Golden Age of floating point computation for another 5 years
3. Numerical Optimization field is mature
4. Key is tight Architecting of Code to Machine – use the available resources.

Basic References:

- [Pink Iguana](#)
- [Numerical Recipes](#)
- [Dennis & Schnabel, Numerical Methods for Unconstrained Optimization and Nonlinear Equations](#)
- [C T Kelly, Iterative Methods for Linear and Nonlinear Equations](#)
- [Hennessey & Patterson, Computer Architecture](#)

Current Market Size

FDIC: US Banks

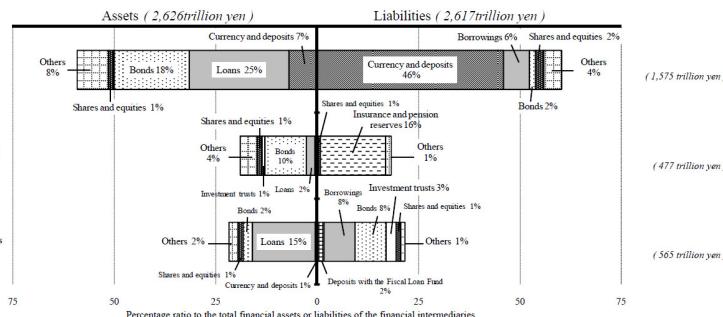
Dollar Amounts in Billions		All Insured Institutions	Commercial Banks	Savings Institutions
Fourth Quarter 2014				
Number of FDIC-Insured		6,509	5,642	867
Number of FDIC-Supervised		4,138	3,719	419
Total Assets	\$	15,554	14,484	1,069
Total Loans	\$	8,309	7,638	671
Domestic Deposits	\$	10,368	9,550	818
Bank Net Income (QTR)	\$	36,919	33,772	3,147
Percent Profitable (QTR)	%	90.6	91.2	86.9
Average Return on Assets (QTR)	%	0.96	0.94	1.19
Average Return on Equity (QTR)	%	8.56	8.44	10.06
Net Interest Margin (QTR)	%	3.12	3.09	3.51
Equity to Assets	%	11.15	11.11	11.77
Noncurrent Loan Rate - Total Loans *	%	1.96	1.95	2.04
Real Estate Loans	%	3.35	3.44	2.57
C&I Loans	%	0.50	0.49	0.77
Loans to Individuals	%	0.89	0.88	1.05
Coverage Ratio **	%	75.38	75.93	69.37
Net Charge-Off Rate - All Loans (QTR)	%	0.48	0.47	0.53
Real Estate Loans (QTR)	%	0.17	0.18	0.11
C&I loans (QTR)	%	0.27	0.26	0.64

Top 20 Global Banks By Assets

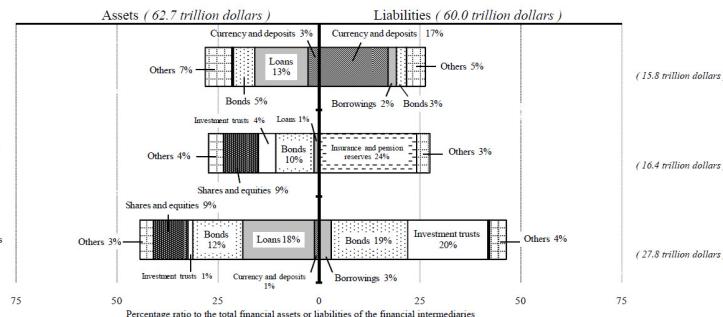
Current Rank	Prev. Rank	Bank	Assets USD m	Loc ccy + Or -	Capital USD	BS Date
1	1	Industrial & Commercial Bank of China Limited, China	3,124,474	7.84%	58,035.91	31.12.13
2	2	China Construction Bank Corporation, China	2,537,402	9.95%	41,292.05	31.12.13
3	3	BNP Paribas SA, France	2,474,078	-5.61%	36,849.92	31.12.13
4	4	Agricultural Bank of China Limited, China	2,405,091	9.95%	53,643.29	31.12.13
5	5	Bank of China Limited, China	2,291,492	9.41%	46,140.19	31.12.13
6	6	Deutsche Bank AG, Germany	2,214,678	-20.32%	3,587.14	31.12.13
7	7	Barclays PLC, UK	2,173,936	-11.82%	3,977.48	31.12.13
8	8	Crédit Agricole SA, France	2,112,250	-4.98%	10,314.73	31.12.13
9	9	Japan Post Bank Co Ltd., Japan	1,961,701	1.34	33,903.79	31.03.14
10	11	JPMorgan Chase Bank National Association, USA	1,945,467	2.57%	1,785.00	31.12.13
11	10	The Bank of Tokyo-Mitsubishi UFJ Ltd, Japan	1,760,014	7.32%	16,583.39	31.03.14
12	12	Société Générale, France	1,697,721	-1.25%	1,371.63	31.12.13
13	13	The Royal Bank of Scotland plc, UK	1,688,912	-20.58%	10,943.86	31.12.13
14	14	BPCE, France	1,544,145	-2.09%	22,251.24	31.12.13
15	15	Banco Santander SA, Spain	1,533,312	-12.13%	7,788.62	31.12.13
16	16	Sumitomo Mitsui Banking Corporation, Japan	1,518,269	3.58%	18,776.46	31.03.13
17	17	Mizuho Bank Ltd , Japan	1,437,609	77.82%	13,600.89	31.03.14
18	18	Bank of America NA, USA	1,433,716	-2.74%	3,020.00	31.12.13
19	19	Lloyds TSB Bank Plc, UK	1,427,395	-9.50%	2,606.39	31.12.13
20	20	Wells Fargo Bank NA, USA	1,373,600	8.49%	519	31.12.13

Balance Sheet Composition by Region

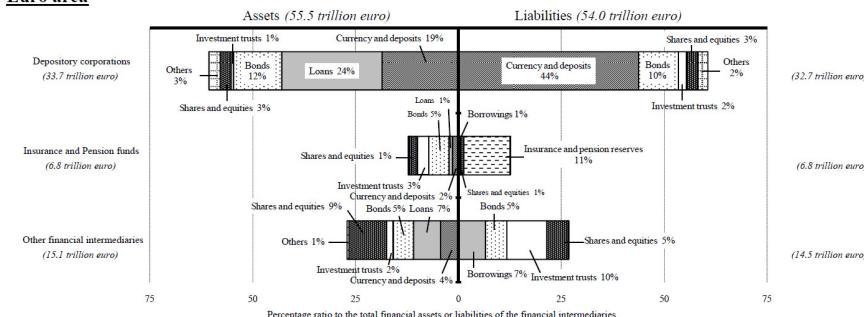
Japan



United States



Euro area



* "Depository corporations" for Euro area includes central bank sector.

** "Others" is the residual which is the remaining after deducting "Currency and deposits", "Deposits with the Fiscal Loan Fund"(Japan only),"Loans", "Bonds", "Investment trusts", "Shares and equities" and "Insurance and pension reserves" from total financial assets/liabilities.

*** "Currency and deposits" held by depository corporations includes "Vault cash" and "Reserves at Federal Reserve".

Market Size

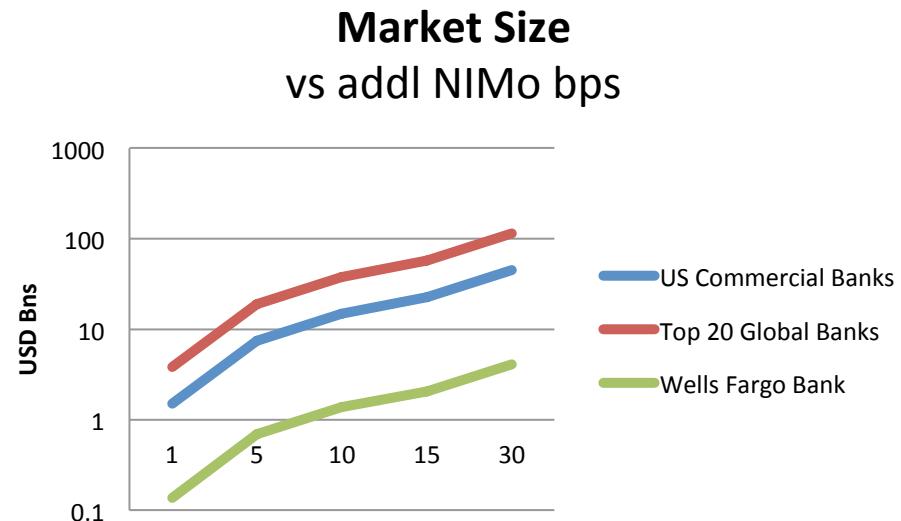
Estimates

McKinsey: Between deluge and drought:
The future of US bank liquidity and
funding 2012

Funding optimization. By reducing their cost of funds, banks can gain a significant lift in margin, which will directly improve the bottom line. Through maximizing low-cost deposit funding, retiring high-cost debt instruments, and repositioning secured funding portfolios, it is possible for many **banks to lower their funding costs by 10 to 15 basis points.**

Large US Bank Historical NIM

	Q1 2011	Q1 2012	Q2 2012	Q3 2012	Q4 2012	Q1 2013	Q2 2013	Q3 2013	Q4 2013	Q1 2014	Q2 2014
U.S. Bancorp	3.69%	3.60%	3.58%	3.59%	3.55%	3.48%	3.43%	3.43%	3.40%	3.35%	3.27%
Wells Fargo	4.05%	3.91%	3.91%	3.66%	3.56%	3.48%	3.46%	3.38%	3.26%	3.20%	3.15%
Citigroup	2.88%	2.90%	2.81%	2.86%	2.93%	2.88%	2.85%	2.81%	2.88%	2.90%	2.87%
Bank of America	2.66%	2.50%	2.20%	2.31%	2.34%	2.36%	2.35%	2.33%	2.44%	2.29%	2.22%
JPMorgan	2.89%	2.61%	2.47%	2.43%	2.40%	2.37%	2.20%	2.18%	2.20%	2.20%	2.19%

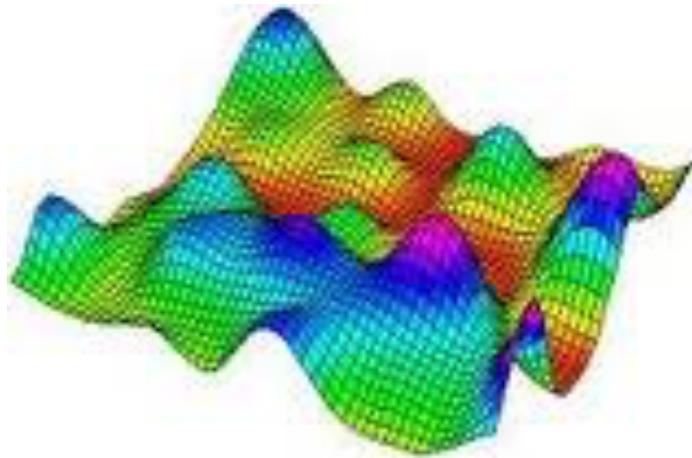


1. Many Trillions of USD on Balance Sheet in Many Large Domestic and Foreign Banks
2. NIM 250 bps to 350 bps
3. Numerical Optimization path to 30+ bps of Added Annual Revenue
4. NIMo Market Easily Could Be 100 BN USD Annually by 2017?

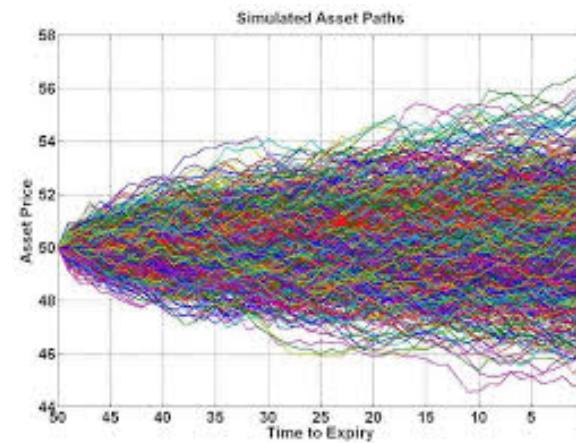
References:

- <https://www.fdic.gov/bank/statistical/stats/>
- <http://www.acuity.com/useful-links/bank-rankings/>
- <http://www.zerohedge.com/sites/default/files/images/user5/imageroot/2012/03/Developed%20World%20balance%20Sheet.jpg>
- <http://www.forbes.com/sites/greatspeculations/2014/09/11/a-quick-comparison-of-interest-margins-for-the-largest-u-s-banks/>

NIMo = NLP over MC over CCAR



NLP – Nonlinear Programming



Monte Carlo



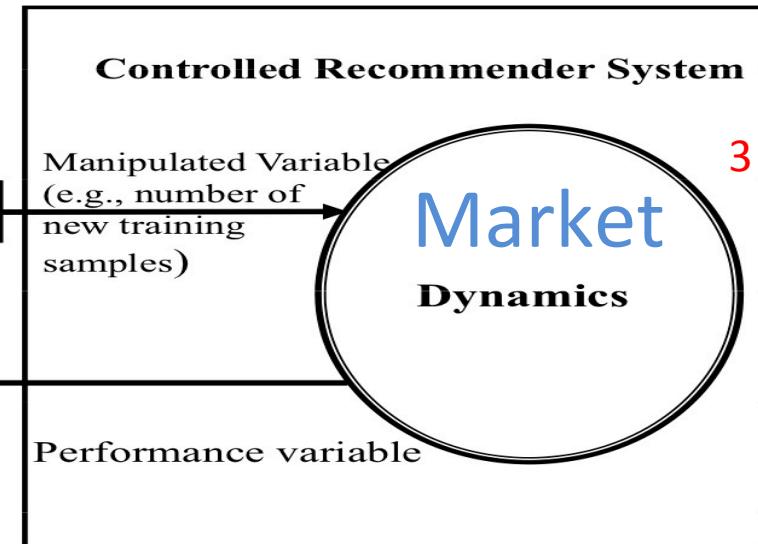
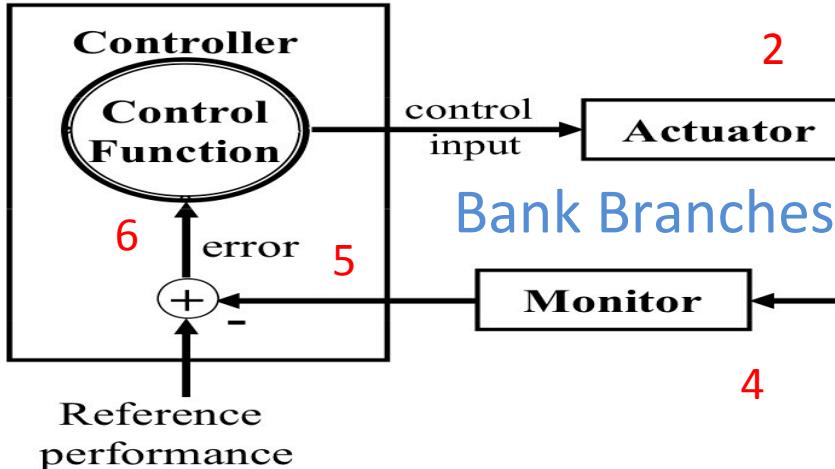
1. Drive NLP/LP search in large parallel machine
2. Pack Monte Carlo + Balance Sheet Sim. onchip
3. NLP/LP just needs to beat what Banks do now

References:

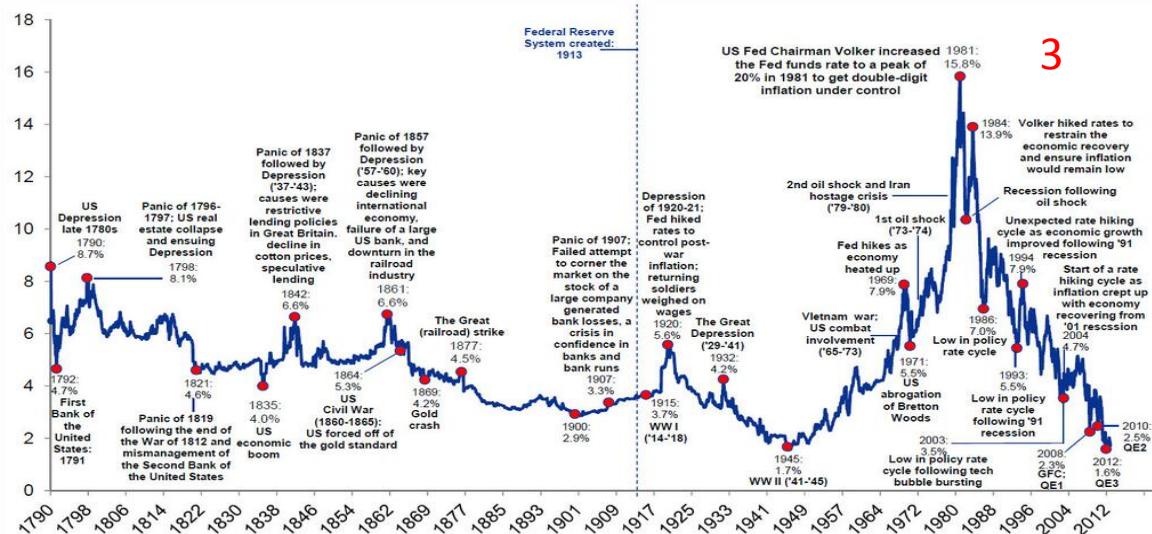
- <http://www.wolfram.com/products/applications/mathoptpro/>
- <http://www.cs.ucsb.edu/~kyleklein/publications/neldermead.pdf>
- <http://www.maths.uq.edu.au/~kroese/montecarlohandbook/>
- <http://www.federalreserve.gov/bankinforeg/ccar.htm>
- <http://www.top500.org/statistics/sublist/>

Balance Sheet Control Theory

NIMo 1



The long history of long (10-year US treasuries) yields



Source: Global Financial Database, Goldman Sachs Global ECS Research. Special thanks to Jose Ursua.

1. NIMo Computes allocation for runoff/ new origination based on CCAR/LMM simulation
2. Bank Branches implement NIMo plan w. some tracking error/attenuation.
3. Market Reacts/Moves
4. Bank Monitors the Realization of NIMo plan and the Market – Capital Allocation Performance Attribution.
5. Bank Inputs Feedback to NIMo
6. NIMo adjusts for plan realization error as well as exogenous market events

NIMo LP

Approach: CCAR worst case analysis is extended to Monte Carlo expected case full balance sheet LMM simulation (on a randomly perturbed CCAR base case scenario). The Bank's CCAR infrastructure provides clean Accrual Portfolio data and a Bank/Regulatory framework for reviewing the Balance Sheet simulations. The balance/return values in the LP are from the Monte Carlo of the full balance sheet simulation. The LP checks the outputs from MC for the various incremental capital allocation plans in X (below) and guides the simplex/interior point method to the risk adjusted optimal NIR (consistent with the market expectations).

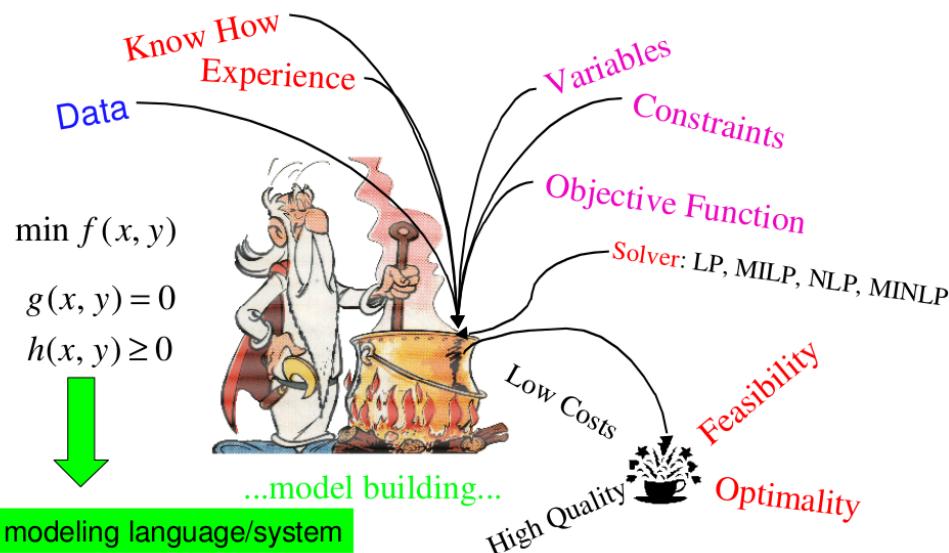
- X contains O(1000) elements
 - NIR output
 - Firm New Investment levels (O(1)) inputs
 - Firm & Regional Risk level constraints (O(100)) outputs
 - Libor, Sovereign, FX, Credit, Vol, and Basis
 - Regulatory level constraints (O (10)) outputs
 - Liquidity Coverage Ratio
 - Net Stable-Funding Ratio
 - Business Entity Balance level constraints (O(1000)) inputs
 - Acquisition, Retention, Runoff goals per GOC (Business Unit)
 - Current Balance Sheet broken down by Business Unit is an input
 - New Product Model Constraints (O(1000)) inputs
 - New origination.
1. NIMo LP dimension ~500,000 variables
300 time steps * (1,000 potential new investments + Reg./Risk Constraints)
 2. Risks: Stochastic market model for Accrual Portfolio contacts.
 3. Risks: Balance and Return Modeling
 4. Risks: Serial library runtime (YB, DP, Intex too slow) not competitive.

References:

- C.T. Kelly, N C State
- A. C. Nemirovski, Georgia Tech
- R. B. Schnabel, Indiana
- A. Ruszczynski, Rutgers

NLP/LP Avg. Runtime Complexity

- $O(n^3)$ simplex LP avg.
- $O(n^{3.5})$ interior point method
- Quasi Newton DFB
BFGS



Hardware cost:

- Assume Daily Balance and Return simulation for entire Balance Sheet for 5Y.
- Assume full BSS on chip Haswell/Broadwell under 10sec. For single large bank
- Assume 2K cores costing \$1mm covers daily BSS + 10K path MC simulation. Minutes/Hours of runtime
- LP dim. NIR $n \sim 500,000$ off the shelf code. Benchmark under 1000 secs. On i7-2600 Linux PC (see Mittleman/Simplex).

1. Low hardware cost - under \$1mm
2. Modest runtime – several hours.
3. Intel/Skylake/Moore's Law is important
4. Code Design Strategy: Get max sub 10 picosecond arithmetic execution

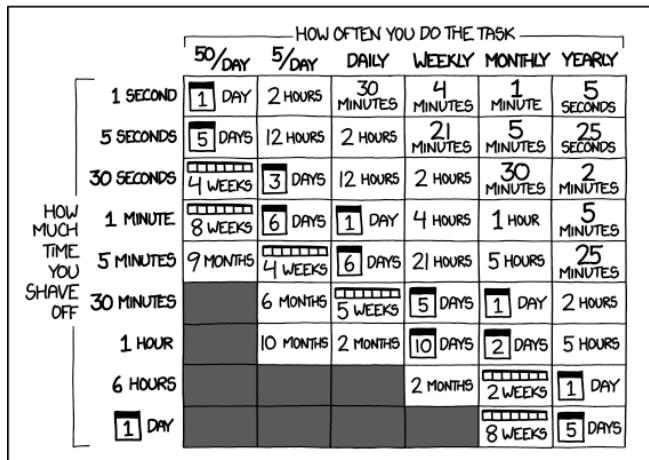
References:

- Sandberg, Citi, Ruby Floating Point 2015.
Sandberg, talk, Finding NIMo, Mar-2015.
Mittleman, Benchmarks for Opt. Software.

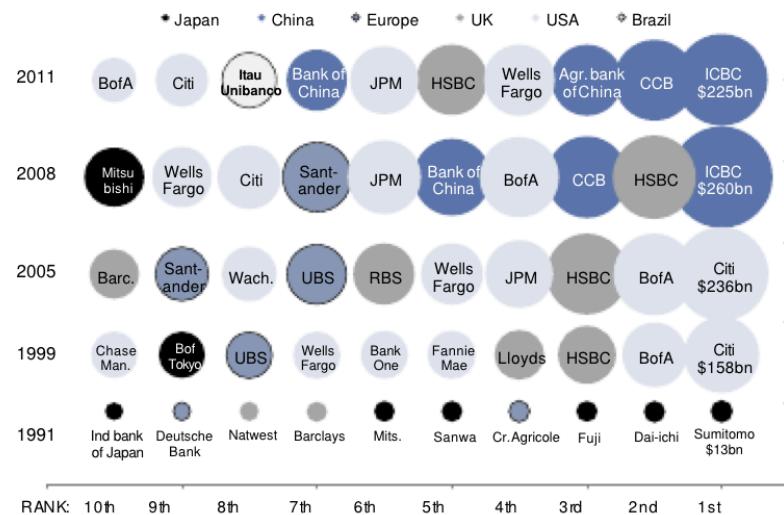
Size Matters?



HOW LONG CAN YOU WORK ON MAKING A ROUTINE TASK MORE EFFICIENT BEFORE YOU'RE SPENDING MORE TIME THAN YOU SAVE?
(ACROSS FIVE YEARS)



The world through a banking lens
Top-10 banks by market cap and region



Source: Datastream.

1. Multi Billion dollar per year new Financial Engineering market to Cray Computer.
 2. Banks under continued pressure to shrink size.
 3. Idea: M&A Undervalued Assets for Sale with Low Rates.
 4. Idea: Model all the ALM in a market, not just one bank.
- References:**
1. Is It Worth the Time, xkcd: <http://xkcd.com/1205/>
 2. Is there a Market? See [here](#) and [here](#). Well, there are some sellers.
-The Bank of England's chief economist, Andy Haldane, said in 2009 that "there is not a scrap of evidence of economies of scale or scope in banking -- of bigger or broader being better."

