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

Why is NIM Forecasting important?
- A bp of NIM ~$180mm of annual revenue for large Balance Sheet.
- +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 running CCAR
2. CCAR cleaning up Balance Sheet data (positions, indicatives, market data)
3. Idea: Make CCAR sunk costs produce revenue

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 per 3-4 picosecond – supply is high
2. Need Vector code issue to get the “free” FLOPS
3. 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
NIM Optimization

Classical Nonlinear Optimization Problem:
Find \( x \) in \( \mathbb{R}^n \), the allocation of capital to
Maximize:
\[
f(x) \quad \text{– The Firm NIM}
\]
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/Full Balance Sheet – it is just now feasible
4. Idea: Automate Bank NIM Growth +30 bps per anum (no compounding)

References:
- FDIC, Remarks by Gruenberg 1Q2013
- FRED, NIM for US Banks
NIMo Timeline

1. In the Golden Age of floating point computation for another 5 years
2. Numerical Optimization field is mature
3. There is accurate clean Accrual Portfolio data now.

Basic References:
- Pink Iguana
- http://www.nr.com
- Dennis & Schnabel, Numerical Methods for Unconstrained Optimization and Nonlinear Equations
- C T Kelly, Iterative Methods for Linear and Nonlinear Equations
- Hennessey & Patterson, Computer Architecture

Trifecta
- Parallel Numerical Optimization
- Free FLOPs
- Full Balance sheet simulation
Current Market Size

FDIC: US Banks

<table>
<thead>
<tr>
<th>Dollar Amounts in Billions</th>
<th>All Insured Institutions</th>
<th>Commercial Banks</th>
<th>Savings Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fourth Quarter 2014</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of FDIC-Insured</td>
<td>6,509</td>
<td>5,642</td>
<td>867</td>
</tr>
<tr>
<td>Number of FDIC-Supervised</td>
<td>4,138</td>
<td>3,719</td>
<td>419</td>
</tr>
<tr>
<td>Total Assets $</td>
<td>$15,554</td>
<td>$14,484</td>
<td>$1,069</td>
</tr>
<tr>
<td>Total Loans $</td>
<td>$8,309</td>
<td>$7,638</td>
<td>671</td>
</tr>
<tr>
<td>Domestic Deposits $</td>
<td>$10,998</td>
<td>$9,650</td>
<td>818</td>
</tr>
<tr>
<td>Bank Net Income (QTR) $</td>
<td>$36,919</td>
<td>$33,772</td>
<td>3,147</td>
</tr>
<tr>
<td>Percent Profitable (QTR) %</td>
<td>90.6</td>
<td>91.2</td>
<td>86.9</td>
</tr>
<tr>
<td>Average Return on Assets (QTR) %</td>
<td>0.96</td>
<td>0.94</td>
<td>1.19</td>
</tr>
<tr>
<td>Average Return on Equity (QTR) %</td>
<td>8.56</td>
<td>8.44</td>
<td>10.06</td>
</tr>
<tr>
<td>Net Interest Margin (QTR) %</td>
<td>3.12</td>
<td>3.09</td>
<td>3.51</td>
</tr>
<tr>
<td>Equity to Assets %</td>
<td>11.15</td>
<td>11.11</td>
<td>11.77</td>
</tr>
<tr>
<td>Noncurrent Loan Rate - Total Loans %</td>
<td>1.96</td>
<td>1.95</td>
<td>2.04</td>
</tr>
<tr>
<td>Real Estate Loans %</td>
<td>3.35</td>
<td>3.44</td>
<td>2.97</td>
</tr>
<tr>
<td>C&amp;I Loans %</td>
<td>0.50</td>
<td>0.49</td>
<td>0.77</td>
</tr>
<tr>
<td>Loans to Individuals %</td>
<td>0.89</td>
<td>0.88</td>
<td>1.05</td>
</tr>
<tr>
<td>Coverage Ratio ** %</td>
<td>75.38</td>
<td>75.93</td>
<td>69.37</td>
</tr>
<tr>
<td>Net Charge-Off Rate - All Loans (QTR) %</td>
<td>0.48</td>
<td>0.47</td>
<td>0.53</td>
</tr>
<tr>
<td>Real Estate Loans (QTR) %</td>
<td>0.17</td>
<td>0.18</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Balance Sheet Composition by Region

Top 20 Global Banks By Assets

<table>
<thead>
<tr>
<th>Current Rank</th>
<th>Prev. Rank</th>
<th>Bank</th>
<th>Assets USD m</th>
<th>Loc ccy + Or - Capital USD</th>
<th>BS Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Industrial &amp; Commercial Bank of China Limited, China</td>
<td>3,124,474</td>
<td>7.84%</td>
<td>58,035.91</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2 China Construction Bank Corporation, China</td>
<td>2,357,402</td>
<td>9.55%</td>
<td>41,292.08</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>BNP Paribas SA, France</td>
<td>2,474,078</td>
<td>-5.6%</td>
<td>36,849.92</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>Bank of China Limited, China</td>
<td>2,291,492</td>
<td>9.41%</td>
<td>46,140.19</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>Deutsche Bank AG, Germany</td>
<td>2,214,678</td>
<td>-20.32%</td>
<td>3,587.14</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>Barclays Bank PLC, UK</td>
<td>2,173,936</td>
<td>-11.82%</td>
<td>3,977.48</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>Crédit Agricole SA, France</td>
<td>2,112,250</td>
<td>-4.98%</td>
<td>10,314.73</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>9 Japan Post Bank Co Ltd., Japan</td>
<td>1,961,701</td>
<td>1.34</td>
<td>33,903.79</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>13 JPMorgan Chase Bank National Association, USA</td>
<td>1,945,467</td>
<td>2.57%</td>
<td>1,785.00</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
<td>10 The Bank of Tokyo-Mitsubishi UFJ Ltd, Japan</td>
<td>1,760,014</td>
<td>7.32%</td>
<td>16,583.39</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>12 Société Générale, France</td>
<td>1,697,721</td>
<td>-1.25%</td>
<td>1,371.63</td>
</tr>
<tr>
<td>13</td>
<td>13</td>
<td>13 The Royal Bank of Scotland plc, UK</td>
<td>1,688,912</td>
<td>-20.58%</td>
<td>10,943.86</td>
</tr>
<tr>
<td>14</td>
<td>14</td>
<td>14 BNP, France</td>
<td>1,544,145</td>
<td>-2.09%</td>
<td>22,251.24</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td>15 Banco Santander SA, Spain</td>
<td>1,533,312</td>
<td>-12.13%</td>
<td>7,788.62</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td>16 Sumitomo Mitsui Banking Corporation, Japan</td>
<td>1,518,269</td>
<td>5.58%</td>
<td>18,776.46</td>
</tr>
<tr>
<td>17</td>
<td>17</td>
<td>17 Mizuho Bank Ltd., Japan</td>
<td>1,437,609</td>
<td>77.82%</td>
<td>13,600.89</td>
</tr>
<tr>
<td>18</td>
<td>18</td>
<td>18 Bank of America NA, USA</td>
<td>1,433,716</td>
<td>-2.74%</td>
<td>3,020.00</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>20 Wells Fargo Bank NA, USA</td>
<td>1,373,600</td>
<td>8.49%</td>
<td>519</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>U.S. Bancorp</td>
<td>3.69%</td>
<td>3.60%</td>
<td>3.58%</td>
<td>3.59%</td>
<td>3.55%</td>
<td>3.48%</td>
<td>3.43%</td>
<td>3.43%</td>
<td>3.40%</td>
<td>3.35%</td>
</tr>
<tr>
<td>Wells Fargo</td>
<td>4.05%</td>
<td>3.91%</td>
<td>3.91%</td>
<td>3.66%</td>
<td>3.56%</td>
<td>3.48%</td>
<td>3.46%</td>
<td>3.38%</td>
<td>3.26%</td>
<td>3.20%</td>
</tr>
<tr>
<td>Citigroup</td>
<td>2.88%</td>
<td>2.90%</td>
<td>2.81%</td>
<td>2.86%</td>
<td>2.93%</td>
<td>2.88%</td>
<td>2.85%</td>
<td>2.81%</td>
<td>2.88%</td>
<td>2.90%</td>
</tr>
<tr>
<td>Bank of Ameri</td>
<td>2.66%</td>
<td>2.50%</td>
<td>2.20%</td>
<td>2.31%</td>
<td>2.34%</td>
<td>2.36%</td>
<td>2.35%</td>
<td>2.33%</td>
<td>2.44%</td>
<td>2.29%</td>
</tr>
<tr>
<td>JPMorgan</td>
<td>2.89%</td>
<td>2.61%</td>
<td>2.47%</td>
<td>2.43%</td>
<td>2.40%</td>
<td>2.37%</td>
<td>2.20%</td>
<td>2.18%</td>
<td>2.20%</td>
<td>2.20%</td>
</tr>
</tbody>
</table>

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

References:
https://www.fdic.gov/bank/statistical/stats/
NIMo = NLP over MC over CCAR

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

References:
http://www.wolfram.com/products/applications/mathoptpro/
http://www.maths.uq.edu.au/~kroese/montecarlohandbook/
http://www.federalreserve.gov/bankinf/foreg/ccar.htm
http://www.top500.org/statistics/sublist/
Balance Sheet Control Theory

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

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

Source: Global Financial Database, Goldman Sachs Global ECS Research. Special thanks to Jose Ursa.
**NIMo NLP**

**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 $g_i(x)$ in the NLP are from the Monte Carlo of the full balance sheet simulation. The NLP checks the outputs from MC for the various incremental capital allocation plans in X (below) and guides the gradient climbing search to the risk adjusted optimal NIM (consistent with the market expectations).

- X contains O(10K) elements
  - NIM 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(10K)) 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 originationA.

1. NIMo NLP dimension 1000 to 10,000
2. Constraints are Sparse
3. Need Parallel Formulation for contemporary computer architecture

**References:**
C.T. Kelly, N C State
A. C. Nemirovski, Georgia Tech
R. B. Schnabel, Indiana
NLP Avg. Runtime Complexity

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

Hardware cost:
- Assume NIMo NLP runs 24 hours
- Assume NIMo 10K path MC+ full BSS on chip Haswell/Broadwell 3000sec.
- Assume 2K cores cost $1mm
- Assume NLP parallelizes and scales
- Current Est. $10$ to $100$ per NLP Evaluation
- NLP dimension $n \sim 1000$

1. Full NIMo Breakeven probably around 1 to 10 cents per NLP evaluation
2. Partial NIMo still likely very profitable
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.
Size Matters?

1. Multi Billion dollar per year new Financial Engineering market to Cray Computer
2. Banks under continued pressure to shrink size.
3. M&A Undervalued Assets for Sale

References:
1. Is It Worth the Time, xkcd: [http://xkcd.com/1205/](http://xkcd.com/1205/)
2. Is there a Market? See [here](http://xkcd.com) and [here](http://xkcd.com). 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..."