A primer on Artificial Intelligence, what is driving the resurgence of the technology, and where it is going in the future
General Disclaimer

Please note that the information and data presented herein is based on reliable sources and, or opinion of Autonomous Research LLP (herein referred to as “Autonomous”). The material within this document has been prepared for information purposes only. This material does not give a Research Recommendation and/or Price Target and thus applicable regulatory Research Recommendation disclosures relating to the same are not included herein. This communication is not a product of the Research department of Autonomous although there may be links or references to Research reports and products.

This communication has been issued and approved for distribution in the U.K. by Autonomous Research LLP only to, and directed at, a) persons who have professional experience in matters relating to investments falling within Article 19(1) of the Financial Services and Markets Act 2000 (Financial Promotion) Order 2005 (the “Order”) or b) by high net worth entities and other person to whom it may otherwise lawfully be communicated, falling within 49(1) of the Order – together Relevant Persons. This material is intended only for investors who are “eligible counterparties” or “professional clients”, and must not be redistributed to retail investors. This communication is not intended to be acted on or relied upon by retail investors.

Retail investors who through whatever means or media receive this material should note that the services of Autonomous are not available to them and should not rely on the contents to make any investment decision. Autonomous shall not be liable for any loss, including any consequential loss which may result from reliance on the information or incurred in respect of any action taken. You are advised to seek your own legal, tax or financial advice accordingly.

Autonomous makes every effort to use reliable comprehensive information, but makes no representation that is accurate or complete. Autonomous assumes no responsibility to update any of the contents or opinions contained and therefore accepts no responsibility for any actions taken on receipt of this communication. The information contained herein and any opinion expressed does not constitute an offer or an invitation to make an offer to buy or sell any securities or financial instrument or derivative relating thereto. The information is not intended to provide personal recommendation or investment advice and it does not take into account the specific investment objectives, financial situation or particular needs of any specific person. Note that income from securities and other financial instruments as well as their value may fall as well as rise and investors may lose their investments. Past performance is not a guarantee for future performance.

In Europe: Autonomous Research LLP is authorised and regulated by the Financial Conduct Authority in the United Kingdom (500498). Registered in England & Wales No OC343985.

This information is provided for your sole use. For the protection of persons (other than a client) who are not authorised to receive this communication, it may not be reproduced in whole or in part by any means except for the personal reference of the intended recipient. No part of this material may be reproduced, distributed or transmitted or otherwise made available without prior consent of Autonomous. Any unauthorised disclosure is strictly prohibited. Copyright Autonomous Research LLP. All rights reserved. The use of external logos are not authorized by, sponsored by, or associated with the trademark owner. Any trademarks and service marks contained herein are the property of their respective owners.
Autonomous NEXT is a mission-driven innovation and fintech analysis process for financial firms and investors

- We are independent, creative and original thinkers about the future of finance serving the world’s largest financial services investors and operators
- We combine both a fundamental and innovation perspective
- Better decisions in financial services = better outcomes for real people
The current metaphor for digitizing the physical world compares human brains with computer systems.

Source: Autonomous NEXT
Note: See G.E. “Digital Twin” initiative
Biggest beneficiaries of the infrastructure build are the high-tech firms, now competing for financial services data.

Public Cloud Application - % of Respondents Running Applications

- AWS: 57% Running Apps, 17% Experimenting, 10% Plan to use
- Azure: 34% Running Apps, 21% Experimenting, 12% Plan to use
- Google Cloud: 15% Running Apps, 17% Experimenting, 13% Plan to use
- IBM: 8% Running Apps, 9% Experimenting, 8% Plan to use
- Oracle Cloud: 7% Running Apps, 8% Experimenting
- DigitalOcean: 5% Running Apps, 4% Experimenting

Source: Rightscale 2017 State of the Cloud Report, Oracle Cloud, Amazon Cloud
The chemistry of the AI ecosystem

**Artificial Intelligence**

**Approaches**
- Expert Systems
- Evolutionary Algorithms
- Planning
- Machine Learning
  - Supervised
  - Unsupervised
  - Reinforcement

**Select concepts**
- Neural Networks
  - Recurrent
  - Adversarial
  - Generative
- Probability & Statistics
  - Bayesian Statistics
  - Markov Models
  - Graph Theory & Clustering
- Decision Trees & Random Forests

**Sensory Applications**
- Text
  - Natural Language Processing
  - Summarization
  - Translation
  - Sentiment Analysis
- Sound
  - Speech to Text
  - Speech Generation
  - Music classification
  - Music generation
- Image
  - Image recognition
  - Computer vision
  - Art identification and generation

Source: Autonomous NEXT, Machine Learning Mastery
The automation of vision opens up many possibilities

Discussion

• In recent years, computer vision has become uncannily competent in recognizing and categorizing faces and a variety of objects

• This was in large part driven by big data available through Google images and Facebook photos

• Neural networks trained on a particular type of subject may prefer to have millions of examples, but once they are mapped for processing, they can be used at scale

• It has become trivial to recognize gender and age, and the technology is being extended into medical diagnostics and entire planet indexing

• The next dimension is time – video can be processed similar to static images to build self driving cars, which require powerful chip hardware

Source: Howold.net, Tesla
Machine vision error rates have decreased below human vision error rates

Error Rate in Image Recognition in the ImageNet Competition (%)

- 2010: AlexNet (28.2%)
- 2011: AlexNet (25.8%)
- 2012: VGG (16.4%)
- 2013: GoogleNet (11.7%)
- 2014: ResNet (7.3%)
- 2014: ResNet (6.7%)
- 2015: ResNet (3.57%)

Human visual recognition error rate at 5%
Machines make mistakes where we do not, but at a lower rate

Deep learning architecture

Source: Image NET, Paddle
What does that really mean?

Example 1

In these examples, the images are transformed with various filters – from those that look at the entire composition of the images, to those that trace edges and find granular shapes – in order to create several additional maps on which correlate with particular objects, like cats, dogs, faces or emotions.

Source: MathWorks, A Spiking Neural Network Based Cortex-Like Mechanism and Application to Facial Expression Recognition
Hardware manufacturers of specialized hardware for machine learning have seen investment and appreciation.

**Growth In Price Of NVIDIA Stock Vs SP 500 Index (01/01/2010 To 12/01/2017)**

Source: Bloomberg, NVIDIA
Artificial Intelligence is being applied across Financial Services

<table>
<thead>
<tr>
<th>Fintech AI Use-cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payments</td>
</tr>
<tr>
<td>Chatbots</td>
</tr>
<tr>
<td>Anti-fraud &amp; Risk</td>
</tr>
<tr>
<td>Credit Underwriting</td>
</tr>
<tr>
<td>Smart Contracts Infrastructure</td>
</tr>
</tbody>
</table>

Source: Autonomous NEXT
Financial chatbot & conversational interface ecosystem

User Interaction layer: Voice & Messaging
- Amazon Echo
- Google Home
- Slack
- Skype
- Twilio
- Viber
- WhatsApp
- Kik
- Line
- Tencent

General Purpose Assistants
- Facebook M
- Alexa
- Siri
- Google Assistant
- Cortana

Investing
- UBS
- TD Ameritrade
- OCBC Bank
- digibank
- erica

Banking & Lending
- Western Union
- Enpays
- Mastercard
- American Express
- PayPal

Payments
- Fintech
- Dyme
- WizeLine

Private Label
- Kasisto
- Teller
- ABE
- DigitalGenius
- finn.ai
- Dyme
- Synechron

Investing
- BOND.AI
- DOBOT
- Polly Portfolio
- Stockflare

Insurance
- INSURIFY
- SPIXII
- nextinsurance
- Lemonade
- leO:

Lending
- habito
- Funds Tiger

Budgeting & Savings (Personal Finance Management)
- Plum
- nerdwallet
- chip
- cleo
- TRIM
- Penny
- Ernest
- Albert
- digit

Wallet & Payments
- Wally
- azimo
- TransferWise
- ChatPay

Developer Tools: Frameworks and AI engines
- Microsoft Azure
- Google
- IBM Watson
- Wit.ai
- api.ai
- Botkit
- Converse AI
- AUTOMAT
- pandorabots
- Chatfuel
- SEQUEL
- gupshup

High Tech Incumbents
- Financial Incumbents
- Private-Label Platforms
- Consumer-Facing Agents

Source: Autonomous NEXT, Botlist.co, BootstrapLabs, VentureBeat
Will there be room for human relationships in a winner-take-all tech platform, like iOS or Android?

### Number of Select Financial Institutions in the United States

- **6,799** Commercial Banks
- **5,996** Credit Unions
- **11,500** Registered Investment Advisors
- **7,070** Family Offices
- **8,000** Hedge Funds
- **3,530** Private Equity Firms

### Number of Apps on Phones (2017, n=200 bloggers)

- **802** Total # of finance apps used by bloggers
- **6** Average # of finance apps used by bloggers
- **35** Highest # of finance apps used by a blogger
- **0** Lowest # of finance apps used by a blogger

- **8978** Total # of overall apps used by bloggers
- **66** Average # of overall apps used by bloggers
- **217** Highest # of overall apps used by a blogger
- **4** Lowest # of overall apps used by a blogger

10% is financial

Source: Autonomous NEXT, Rockstar Finance, FDIC, Reuters, SEC, BCG
Example of private-labeled chatbot platform

finn.ai

Overview

• The company provides banks with a chatbot technology that integrates into core processors and conversational apps (e.g., Messenger)

• Currently working with T1 and T2 banks across 4 continents, Finn.ai is automating hyper-frequency front office tasks that results in up to 50% time savings for support staff

• The system is a rule-based agent, making decisions based on a given set of scenarios

• Company uses data aggregator, MX, which extracts consumer information from their online banking services.

• Plans to use machine learning and voice recognition to create ‘behavior profiles’, allowing users to receive personalised advice based on their characteristics, sentiments and cash flows

Raised: $3 Million

Founded: 2014

Source: Autonomous NEXT, Finn.ai
Market Landscape for AI and Advanced Analytics Regtech

- **KYC / AML**
  - True Identity Suite
  - Comply Advantage
  - truoly
  - encompass
  - IdentityMind
  - kompli-global
  - verato
  - onfido
  - PassFort
  - SOCURE

- **Biometrics & Identity**
  - BIOCATCH
  - Cydentify
  - OmniPerception
  - APOLLO
  - trueface.ai
  - ThisisMe
  - uniphore
  - SIGNZY
  - PRIFENDER

- **Compliance Workflows**
  - NETaLogic
  - Cognitive Scale
  - CORLYTICS
  - contracts
  - GOVERNANCE.io
  - TEMENOS
  - FUNDAPPS

- **Cyber Security**
  - DARKTRACE
  - CORE SECURITY
  - RISKIQ
  - IBM Watson
  - Forcepoint
  - Nehemiah Security
  - Syntel
  - VECTRA
  - VERT sell
  - LogRhythm

- **Fraud Detection & Prevention**
  - NetGuardians
  - ThreatMetrix
  - PROVENIR
  - feedzai
  - IBM Watson
  - zened

- **Compliance Workflows**
  - DETECTICA
  - CORLYTICS
  - contracts
  - GOVERNANCE.io
  - TEMENOS
  - FUNDAPPS

- **Diligence & Vendor Risk Management**
  - kompli-global
  - DueDil
  - intiX
  - ARACHNYS
  - A.M.E.

- **Financial Risk Management**
  - AlgoDynamix
  - AQMETRICS
  - Argos
  - CreditPoint
  - Digital Reasoning

- **Surveillance / E Comms**
  - BEHAVOX
  - ANCOA
  - neurensic
  - Stride
  - CheckRecipient

- **Complex, multi-step processes**
  - Operating Use-Cases
  - Transactions

Source: Autonomous NEXT
Complexity of middle office requirements has risen, as has funding for companies using software to lighten the burden.

- The last decade has seen a steady increase in writing dedicated to financial regulation.

Source: Autonomous Research, Mercatus Center

- To deal with the increasing complexity of regulation, compliance and fraud, early stage investors have been funding RegTech as a theme.
Example of machine learning solution for Compliance

Digital Reasoning

Overview

- Synthesys® cognitive computing platform is able to holistically analyze huge volumes, multiple streams and forms of data

- By unifying data around a customer, their activities, needs and intentions, cognitive computing uses machine learning and natural language processing to understand what customers are talking about, their sentiment and buying behaviors

- Deploys bespoke solutions for multiple use-cases across industries:
  - Understanding financial markets
  - Customer profiling, relationship management and cross-selling
  - Government analytics
  - Conduct surveillance and risk management within internal communications

- Investors include BNP Paribas, Barclays, Goldman Sachs, Square Capital, and Nasdaq

Source: Autonomous NEXT, Digital Reasoning
Market Landscape for AI in Product Manufacturing

- **Repayment and Collections**
  - TrueAccord
  - Pairy
  - specto

- **Credit Underwriting**
  - AIDYIA
  - Kimever
  - iTez
  - BlackRock
  - CANTAB
  - sentient technologies

- **AI/Quant funds and software**
  - NUMERAI
  - BINATIX
  - Tickermachine
  - Quantopian
  - Quantiacs
  - Two Sigma
  - Point72
  - Renaissance
  - Worldouvre

- **Claims/Risk Management**
  - Galaxy.AI
  - we see
  - flamingoAI
  - Shift Technology
  - UNDERSTORY
  - risk genius
  - CYENCE
  - Capricity

- **Underwriting**
  - Cytora
  - trov
  - CARPE DATA
  - LAPETUS
  - DreamQuark
  - CAPE ANALYTICS
  - Zendrive
  - OCTO
  - BIGCLOUD

- **Augmented Analyst**
  - ai
  - agolo
  - PRIMER
  - KENSIGON
  - narrative science
  - prattle
  - estimize

- **Banking & Lending**
  - Affirm
  - Underwrite.ai
  - Upstart
  - OnDeck
  - ADF
  - James
  - Aire
  - Trade Quorum

- **Investment Management**
  - CITADEL
  - Winton
  - Renaissance
  - Worldouvre

- **Insurance**
  - Incumbents
  - Autonomous NEXT, Coverager, Oxbow Partners
AI Digital lender model performance by vintage

Cumulative loss rates as a % of originations by loan vintage

Source: Image NET, Paddle, Elevate August 2018 Investor Presentation

The 2017 and 2018 vintages are not yet fully mature from a loss perspective – expected to be slightly better than 2016.
Example of an industry-leading Quantamental fund

**BLACKROCK**

**Overview**

- BlackRock is embracing quantamental strategy by placing its Scientific Active Equity unit at the core of its fundamental stock-picking products. This is separate from its quantitative, factor driven smart beta products.

- The unit and its 80 staff (of which 30 are PhDs) use alternate data sources to enhance the fundamental decision making process:
  - Satellite imagery to understand extent of commercial activity and traffic patterns
  - Conference call transcripts to interpret current affairs, using semantic analysis and levels of specificity
  - Social media to gather real-time sentiment
  - Google trends to decipher public interest and economic trends
  - Employee satisfaction on Glassdoor
  - Online invoices

- 89% of SAE’s assets have outperformed their benchmarks over past 3 years net of fees, and 95% have outperformed over 10 years

**Fund Size:** $100 Billion

**Employees:**
- 80 FTEs
- 30 PhDs

BlackRock’s SAE arm outperforms its traditional stock pickers

% of assets under management above benchmarks (as of Dec 31 2017)

Source: company
© FT

Fundamental Research
Big Data
Machine Learning

Source: Autonomous NEXT, BlackRock, Financial Times, Reuters
Example of image recognition in insurance claims

- Tractable ingests large data set of photos of damaged car parts and associated claims estimates; machine learning creates associations between visual images and expected costs.

- Algorithm with UI can allow much faster claims processing – customer can take photo of damage and receive estimate in real time.

- Applicable to automated body shop adjustments, hail damage, roof inspection, and other use-cases.

- Instead of claimants, company drones can also perform the same task in the future.

- Difficult cases with low image recognition certainty can be directed to more specialized human service.

Source: Autonomous NEXT, Tractable
Total impact across financial sectors is $1 trillion, a 22% traditional cost reduction

**Banking**

<table>
<thead>
<tr>
<th>Revenue</th>
<th>Operating Margin</th>
<th>Costs</th>
<th>Unrelated Costs</th>
<th>AI-Eligible Costs</th>
<th>AI Impact</th>
<th>Remainder</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,255</td>
<td>902</td>
<td>1,353</td>
<td>506</td>
<td>847</td>
<td>447</td>
<td>400</td>
</tr>
</tbody>
</table>

**Investment Management**

<table>
<thead>
<tr>
<th>Revenue</th>
<th>Operating Margin</th>
<th>Costs</th>
<th>Unrelated Costs</th>
<th>AI-Eligible Costs</th>
<th>AI Impact</th>
<th>Remainder</th>
</tr>
</thead>
<tbody>
<tr>
<td>754</td>
<td>226</td>
<td>528</td>
<td>151</td>
<td>377</td>
<td>199</td>
<td>178</td>
</tr>
</tbody>
</table>

**Insurance**

<table>
<thead>
<tr>
<th>Premiums (excludes Other Revenue)</th>
<th>Operating Margin</th>
<th>Costs</th>
<th>Unrelated Costs</th>
<th>AI-Eligible Costs</th>
<th>AI Impact</th>
<th>Remainder</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,339</td>
<td>434</td>
<td>2,905</td>
<td>577</td>
<td>2,328</td>
<td>392</td>
<td>1,937</td>
</tr>
</tbody>
</table>

Source: Autonomous NEXT estimates
In a blue sky scenario, banks could cut ~40% of costs over the next decade, however most banks are not ready.

- At its essence, a bank is its product factories its distribution channels and the processes (compliance, accounting, marketing, administration etc.) linking the two.

- Automation impacts all these aspects of a bank, with significant room for cost reductions.

Source: Autonomous Research
Long term potential savings reaching as high as 42% for retail banks

### Estimated retail cost savings breakdown

<table>
<thead>
<tr>
<th>Distribution</th>
<th>% of Current Cost</th>
<th>Cash Equivalent</th>
<th>Long term potential Savings (%)</th>
<th>Long term potential Savings (Euro M)</th>
<th>5 year potential savings (%)</th>
<th>5 year potential savings (Euro M)</th>
<th>5 year adjusted savings (%)</th>
<th>5 year adjusted savings (Euro M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branches - cost of premises</td>
<td>4%</td>
<td>8,654</td>
<td>-81%</td>
<td>(7,033)</td>
<td>-41%</td>
<td>(3,517)</td>
<td>-29%</td>
<td>(2,501)</td>
</tr>
<tr>
<td>Security</td>
<td>3%</td>
<td>7,072</td>
<td>-76%</td>
<td>(5,392)</td>
<td>-38%</td>
<td>(2,696)</td>
<td>-27%</td>
<td>(1,917)</td>
</tr>
<tr>
<td>Tellers/cashiers</td>
<td>7%</td>
<td>16,843</td>
<td>-81%</td>
<td>(13,688)</td>
<td>-41%</td>
<td>(6,844)</td>
<td>-29%</td>
<td>(4,867)</td>
</tr>
<tr>
<td>Other distribution staff costs</td>
<td>13%</td>
<td>29,472</td>
<td>-40%</td>
<td>(11,789)</td>
<td>-20%</td>
<td>(5,894)</td>
<td>-14%</td>
<td>(510)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>27%</strong></td>
<td><strong>62,041</strong></td>
<td><strong>-61%</strong></td>
<td><strong>(37,902)</strong></td>
<td><strong>-31%</strong></td>
<td><strong>(18,951)</strong></td>
<td><strong>-16%</strong></td>
<td><strong>(9,795)</strong></td>
</tr>
</tbody>
</table>

| Internal processes                  |                   |                 |                                 |                                    |                             |                                  |                             |                                   |
| Risk management                     | 5%                | 11,669          | -50%                            | (5,835)                             | -25%                        | (2,917)                          | -18%                        | (2,075)                          |
| Compliance                          | 5%                | 11,856          | -30%                            | (3,557)                             | -15%                        | (1,778)                          | -11%                        | (1,265)                          |
| Processing, data handling etc       | 32%               | 73,652          | -70%                            | (51,556)                            | -35%                        | (25,778)                        | -25%                        | (18,333)                        |
| **Total**                           | **42%**           | **97,177**      | **-63%**                        | **(60,948)**                        | **-31%**                    | **(30,474)**                     | **-22%**                    | **(21,672)**                     |

| Non addressable costs               |                   |                 |                                 |                                    |                             |                                  |                             |                                   |
| Technology                          | 16%               | 37,341          | 0%                              | 0                                  | 0%                          | 0                                 | 0%                          | 0                                 |
| Other                               | 16%               | 36,826          | 0%                              | 0                                  | 0%                          | 0                                 | 0%                          | 0                                 |
| **Total**                           | **32%**           | **74,167**      | **0%**                          | **0**                              | **0%**                      | **0**                             | **0%**                      | **0**                             |

| **Grand Total**                     | **100%**          | **233,386**     | **-42%**                        | **(98,850)**                       | **-21%**                    | **(49,425)**                     | **-13%**                    | **(31,467)**                     |

*The lion’s share of cost savings coming from:*
- The adoption of a “flagship store” model reducing the need for branches, staff, and security
- Legal Reporting, credit risk profiling, and data processing, however the human element is still crucial to other processes
- Banks competing as digital entities are unlikely to cut technology spending

Source: Autonomous Research estimates
Digitisation looks likely to be a costly process

Cost Impact of Digitisation across Retail Banks

- Recently, digitisation in banks has been mostly about cost inflation at Nordea, yet banks such as Swedbank, Danske and Handelsbanken rather focus on material cost inflation.

- Revenues can also see an impact as changing client behaviour and new regulation exposes banks to disintermediation in more profitable areas such as consumer finance, payments, mortgages, FX transfers and other areas.

- We note that these revenue risks are likely higher for banks not investing in IT, as their offering will be further inferior to what new entrants can offer.

Source: Autonomous Research estimates
Nordic banks are some of the most digitised in the world

Source: Autonomous Research estimates

### Extent of Digitisation Adoption

<table>
<thead>
<tr>
<th>Bank Name</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSBC</td>
<td>SWEETSPOT - Long Term Winners</td>
</tr>
<tr>
<td>Commerz</td>
<td>SWEETSPOT - Long Term Winners</td>
</tr>
<tr>
<td>Rabobank</td>
<td>GOOD OUTLOOK BUT SOME CURRENT WEAK SPOTS</td>
</tr>
<tr>
<td>SHB</td>
<td>GOOD OUTLOOK BUT SOME CURRENT WEAK SPOTS</td>
</tr>
<tr>
<td>DNB</td>
<td>LONG TERM WINNERS</td>
</tr>
<tr>
<td>CredAg</td>
<td>LAGGARDS</td>
</tr>
<tr>
<td>TD Bank</td>
<td>LAGGARDS</td>
</tr>
<tr>
<td>JPM</td>
<td>LAGGARDS</td>
</tr>
<tr>
<td>BBVA</td>
<td>LAGGARDS</td>
</tr>
<tr>
<td>ABN AMRO</td>
<td>LAGGARDS</td>
</tr>
<tr>
<td>Nordea</td>
<td>LAGGARDS</td>
</tr>
<tr>
<td>Bk of Ireland</td>
<td>LAGGARDS</td>
</tr>
<tr>
<td>M&amp;T</td>
<td>LAGGARDS</td>
</tr>
<tr>
<td>Deutsche</td>
<td>LAGGARDS</td>
</tr>
<tr>
<td>Scotia</td>
<td>LAGGARDS</td>
</tr>
<tr>
<td>BB&amp;T</td>
<td>LAGGARDS</td>
</tr>
<tr>
<td>SocGen</td>
<td>LAGGARDS</td>
</tr>
<tr>
<td>HSBC</td>
<td>STRONG ON DIGITAL BUT UNCERTAIN OUTLOOK</td>
</tr>
<tr>
<td>Intesa</td>
<td>STRONG ON DIGITAL BUT UNCERTAIN OUTLOOK</td>
</tr>
<tr>
<td>RBI</td>
<td>STRONG ON DIGITAL BUT UNCERTAIN OUTLOOK</td>
</tr>
<tr>
<td>Unicredit</td>
<td>STRONG ON DIGITAL BUT UNCERTAIN OUTLOOK</td>
</tr>
<tr>
<td>MUFG</td>
<td>STRONG ON DIGITAL BUT UNCERTAIN OUTLOOK</td>
</tr>
<tr>
<td>Mizuho</td>
<td>STRONG ON DIGITAL BUT UNCERTAIN OUTLOOK</td>
</tr>
<tr>
<td>First Horizon</td>
<td>STRONG ON DIGITAL BUT UNCERTAIN OUTLOOK</td>
</tr>
<tr>
<td>RBS</td>
<td>STRONG ON DIGITAL BUT UNCERTAIN OUTLOOK</td>
</tr>
<tr>
<td>PKO</td>
<td>STRONG ON DIGITAL BUT UNCERTAIN OUTLOOK</td>
</tr>
<tr>
<td>Erste</td>
<td>STRONG ON DIGITAL BUT UNCERTAIN OUTLOOK</td>
</tr>
<tr>
<td>CaixaBank</td>
<td>STRONG ON DIGITAL BUT UNCERTAIN OUTLOOK</td>
</tr>
</tbody>
</table>

Our proprietary screening puts most Nordic Banks as leaders in retail bank digitisation.
# Our Ranking Model Methodology

## Bank Ranking Model

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Company financials</th>
<th>Bespoke survey</th>
<th>Customer-provided</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Existing state of digitalisation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Web visits per client</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Client engagement levels*</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>% views from social media</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Mobile app functionality</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Mobile app popularity</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Volatility in mobile app popularity*</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Branch closures</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>IT spend</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Front office innovation indicator</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Cost/income ratio</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td><strong>Transformation outlook</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Board IT experience</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Exco IT experience</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Trend in IT spending</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Improvement in cost/income</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Trend in mobile app popularity</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Middle off innovation indicator</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Back office innovation indicator</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Client innovation indicator</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>

## Internet Banking Usage (2018)

Source: Autonomous Research estimates
The Digitisation of Retail Banks – Benefits achieved

Source: Autonomous Research estimates
Cash is costly – Security and infrastructure costs are burdens to retail banks

- As a side note, digitisation tends to reduce cash usage in society.
- Cash is costly – ATMs, security are direct costs. In addition physical cash is not held in deposits and does not generate payment commissions.

Source: Autonomous Research estimates, Company data, Bloomberg
Banks vs. FinTechs

- Banks have financial resources, and have stepped up spending in recent years.
- In addition there are examples of incumbents building very compelling products. Nordic banks' new initiatives in the payments space is an example of this – somewhat tempered by Klarna’s success.
- However, Tech people are relatively rare in the c-suite and board level of banks. We are surprised by how few of the banks’ non-executive directors have a technology background. Of the 720+ directors across the 59 banks, we believe that only 43 (or 6%) have a background in technology.
- Most banks will have a COO, but only just over half have a dedicated chief technology officer or equivalent (head of digital, innovation transformation etc).
- Dedicated technology directors account for just 6% of the C-suite at the 59 banks in our sample.
- We believe banks are held back by legacy infrastructure, where the core often dates back to the 1980’s.

Banking App Rankings

- Banks technology offerings can be competitive

Number of non-executive directors with a tech background (66 banks)

- Non-executive directors with Tech backgrounds are still a rarity

Change in additions to software intangibles 2015-2017 versus 2012-2014

- Most banks have stepped up their spending on software

Source: Autonomous Research estimates