

# How do banks apply AI to Capital Markets?

Francois Friggit, Holberton School, August 11th, 2021

## Quick resume

- **Current position** : Global head of Models and Valuation Processes at Santander Capital Markets
- **Experience** : 28 years as “quant” (quantitative analyst) in Paris (2 years), New York (3 years), Londres (7 years) et Madrid since June 2005  
Before that, 5 years as engineer specialized in rural development in Burkina Faso, West Africa
- **Studies** : Engineer at Ecole Polytechnique, France, 1985  
Engineer in hydraulics at ENGREF, France, 1987  
Master in International Finance at HEC, France, 1993

**The opinions expressed in this presentation only engage the author,  
and absolutely not any entity with which he is or has been linked,  
in any possible way**

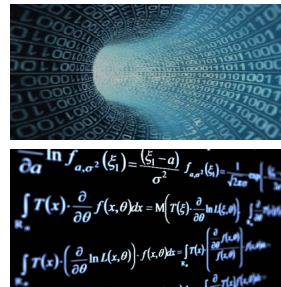
## How do banks apply AI to Capital Markets?

- What is Artificial Intelligence?
- What kind of AI applications do banks implement?
- How do they get organized?

# What is Artificial Intelligence?

## A modern way to analyze and solve problems with data and mathematics

- ... trying to replicate/improve some human cognitive processes
- One particular branch : Machine Learning (ML). Learn patterns from data.
- Deep Learning (DL) = particular case of Machine Learning using Neural Networks technique

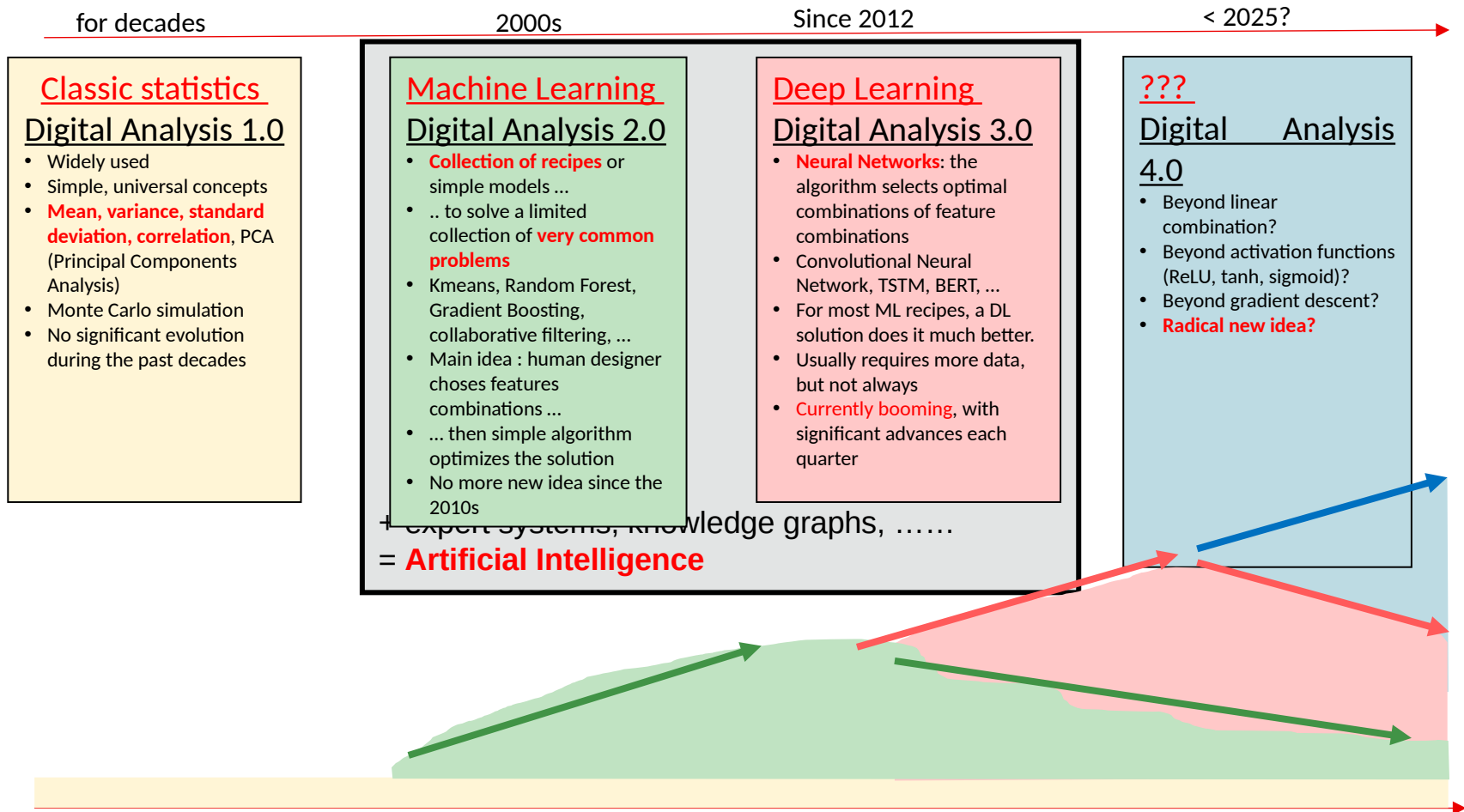


## Typical problems to solve

- “Classification”: customers segmentation, products classification, medical diagnosis, face recognition, fraud detection, ...
- “Prediction”: weather, molecule properties, price adjustments, recommendation engines, automatic translation, question answering, trucks fleet management, ...



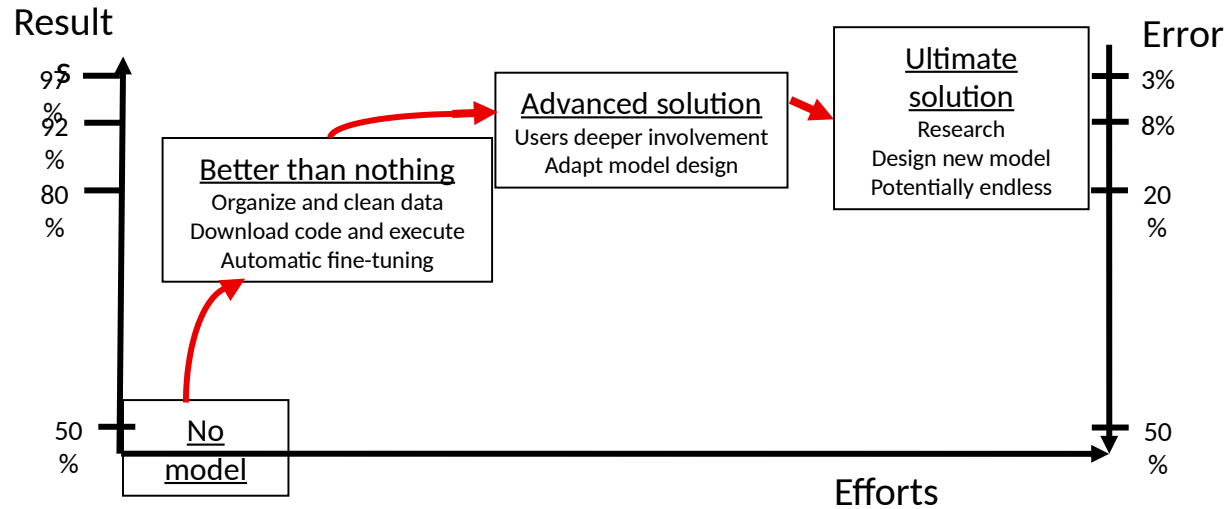
# Historical perspective



# Find the optimal strategy

Let's assume that no model = 50% good results

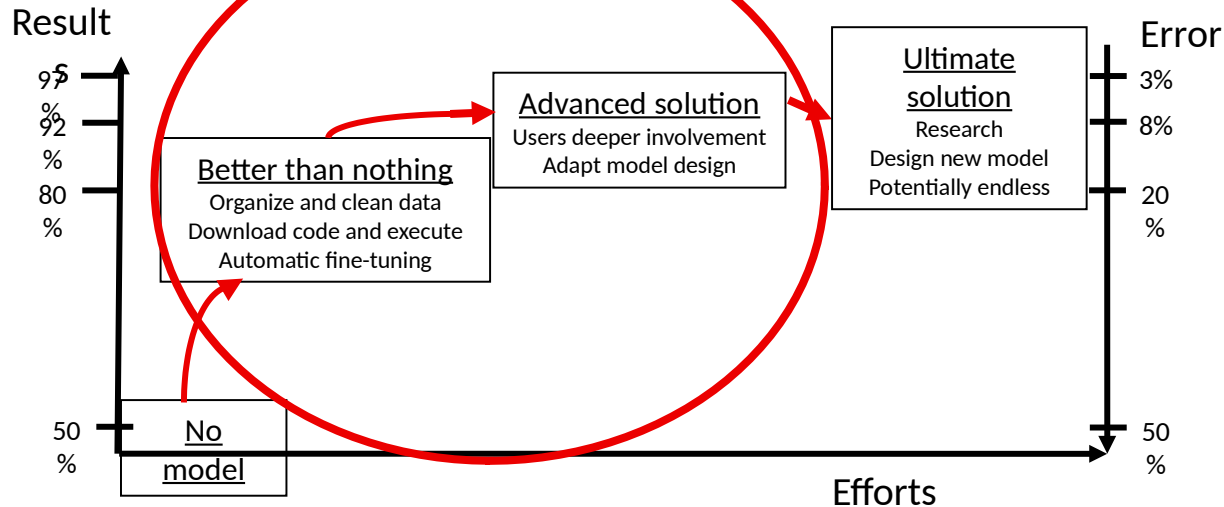
Example : Will market go up or down tomorrow?



# Find the optimal strategy

Let's assume that no model = 50% good results

Example : Will the car turn right or left?



## Key to success

- Opensource frameworks (ScikitLearn, Tensorflow, Keras, PyTorch,...) allow you to program a first “better-than-nothing” program that works
- For each problem, correctly position the desired solution on this figure

Mainly depends on users' tolerance to error

# Machine Learning/Deep Learning frameworks

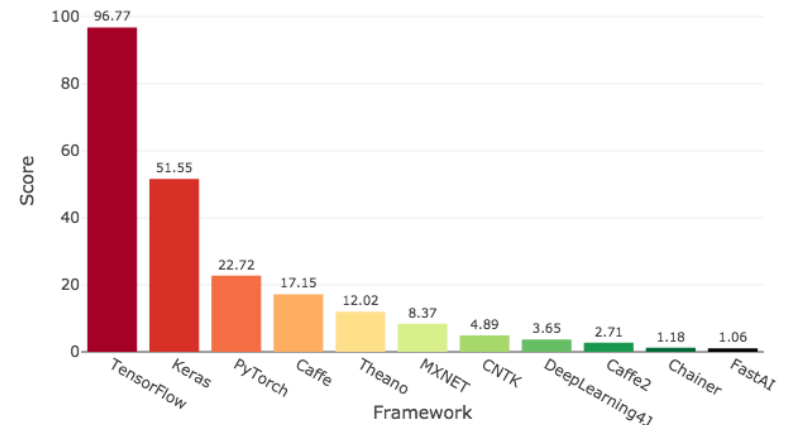
## Why use a ML/DL framework? Low entry cost

- A collection of high- and medium-level functions to easily program ML and DL models
- Allows to program a NN that gives a result in 20-40 lines. Later, weeks of work needed to improve your NN.
- Above all, computation adaptation to your GPU/TPU/hardware come for free ....
- ... together with automatic differentiation, absolutely needed for gradient descent training

## History + current situation/panorama

- Started with R (statistician language), then evolve into Python , Java, and other ad-hoc languages. Today, standard = Python
- ML framework: leader = **ScikitLearn**. Tends to be integrated in DL frameworks
- DL frameworks initially developed by top universities in early 2010s, then reshaped and improved by GAFAs
- **Tensorflow** (Google) is leader. Version 2.0 released in Q1 2019
- **PyTorch** (Facebook) more flexible, used in research and universities. Caffe2 (Facebook) more adapted for production
- **Keras** (Google) on top of Tensorflow, simpler and more intuitive. Ad.hoc version now included in Tensorflow 2.0
- MxNet (Amazon), CNTK (Microsoft), Gluon (API on top of MxNet and CNTK), Paddle (Baidu)
- Natural Language Processing (NLP) specific frameworks: **NLTK** is "older", still more complete, **SpaCy** is more recent, growing fast
- NLP pre-trained models, not frameworks : **BERT** (Google), **GPT-3** (OpenAI), ...
- Opensource, and many contributors

Deep Learning Framework Power Scores 2018



<https://towardsdatascience.com/deep-learning-framework-power-scores-2018-23607ddf297a>  
<https://skymind.ai/wiki/comparison-frameworks-dl4j-tensorflow-pytorch>



## How do banks apply AI to Capital Markets?

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## Sources – recent YouTube videos

### By decreasing interest

- Humans & AI in Financial Services - The Future - Samik Chandarana | ODSC Europe – JPMorgan - Nov 2019  
<https://www.youtube.com/watch?v=DcM4SkJDvi8> – Best from 05mn20s to 18mn55s
- Formula for Success: AI + Human Intuition = Differentiated Insights | Jeff McMillan, Morgan Stanley – June 2019  
<https://www.youtube.com/watch?v=0tdsu2xfWuY> – Best from 06mn40s to 13mn50s
- How Credit Suisse Is Leveraging Open Source Data and AI Platforms | Keynote Spark + AI Summit - June 2020  
[https://www.youtube.com/watch?v=pKZBVJ4\\_i94](https://www.youtube.com/watch?v=pKZBVJ4_i94) – best from 01mn00s to 10mn30s
- Running a CoE for Self-Service Data Science by Nicholas Bignell, UBS Investment Bank – Nov 2018  
<https://www.youtube.com/watch?v=RxNH5ZF7ppg>
- Goldman Sachs' Dr. Charles Elkan – AI World – Oct 2019 <<https://www.youtube.com/watch?v=APHp3WrC5AM>>
- Banque & machine learning : Société Générale optimise le traitement de documents (OCR et IA) – Oct 2019  
<https://www.youtube.com/watch?v=4QHU7lyjbk4>

AI in financial industry podcast by Dan Faggella – weekly  
<https://emerj.com/ai-in-financial-services-podcast/>

## JP Morgan applications

## Comments on RoboTrader

- Only AI application approved by regulators so far
- Key: the machine “puts its hands up” when it cannot decide on its own, requiring help from human

## Examples of projects already deployed



## RoboTrader

### Quote – Execute – Hedge

End-to-end framework for quoting, executing & hedging of equity derivative trades. RoboTrader is able to price client trades, manage the portfolio & execute trades electronically



### R3 – Reconciliations: Reduction and Resolution

Humans + Machine = Impact

Identify patterns from historical manual matches and suggest probable matches for new reconciliation breaks. ML model helps in a faster and a reconciliation process.

Figure 1 illustrates the experimental setup. A participant is seated at a table, looking at a screen. On the screen, there is a starting point (a large circle) and a target (a small circle). The distance between the starting point and the target is labeled 'Distance'. The participant's hand is positioned at the starting point and is labeled 'Hand'.

J.P.Morgan

## JP Morgan applications (2)

### Comments on applications

- In 2019 reconciliation should be performed by machines, not by humans any longer!
- LIBOR transition: legal documentation review
- STAR: What are market people about to do?
- Email virtual assistant: prepare sensible reply

### General comments

- You're never done with AI. You constantly need to improve, or at least adapt to context evolution

### Other Examples from our Applied Teams

	Client Reference Data Remediation		Activism
	Libor Transition		Role Based Access Control (RBAC)
	Markets Surveillance Toolkit		Sales & Trading Analytics Recommender (STAR)
	E-mail Virtual Assistant		Prospecting

J.P.Morgan

# Credit Suisse applications

## CS comments on applications

- Graph analysis is extremely important at CS
- ML sandbox allows to democratize AI, deploying very quickly

## Other comments

- Traders are looking for real-time intelligence on how to price, how to manage inventory, how to drive RFQs
- Sales are looking for insight on which products customers are interested in
- Research is trying to differentiate our contents to clients

## Machine Learning & Data Mining

### Natural Language Processing

- Tonality & Sentiment models
- Topic detection
- Event detection
- Emotion detection
- Text Summarization

### Graph Analytics & Pattern Mining

- Community detection
- Strongly connected entities
- FP Growth
- Sequence Mining

### Predictive Analytics

- Anomaly detection
- Time series univariate and multivariate forecasting
- Recommendation engines
- Pricing and Fundamental analysis

### ML Sandbox

#### NLP Image

Ex. BERT, Tensorflow, PyTorch, ELMo (Allennlp), VADER, Spark NLP, Spacy, NLTK, Word2vec, Glove

#### Quant/Predictive Image

Ex. FB Prophet, Tensorflow probability, Pandas, Pandas Profiling, Zipline, Pyfolio

#### IDE

Databricks Notebooks

#### Compute

Scale Out: Apache Spark  
Scale Up: GPU

#### ML Lifecycle Management

MLFlow

#### Visualization

Tableau, Databricks, Seaborn, Matplotlib

# Applications + models

## Markets

- Market data simulation ☐
- Portfolio simulation
- Fast pricing
- Cross-markets influence
- Algo trading/hedging
- Markets regime detection, markets surveillance with alerts

## Markets + customers

- Intelligent pricing
- Recommendation engines
- Transactions analysis ☐
- Voice command

## Customers

- Information extraction from call reports, chats, news ☐
- Customer behavior analysis, sentiment analysis, topic detection, anomaly detection ☐
- Customers and products segmentation
- News analysis for DCM (like Equity Capital Markets)

## Models and techniques

- Random Forest, Gradient Boosting
- Convolution Neural Networks
- Recurrent Neural Networks LSTM
- Auto-Encoders, GANs
- Active Learning
- Graph Neural Networks
- Time series analysis
- Reinforcement Learning
- Collaborative Filtering (+Deep)
- NLP – Speech recognition
- NLP – advanced OCR
- NLP – sentiment analysis
- Knowledge graphs
- Clustering/classification

## Process control

- ☐ Data quality check, data cleansing
- Reconciliation
- Software maintenance & support

## Documents

- Information extraction from documents and contracts, CSA/CSD agreements, Term sheets (IBOR)
- Documents/reports generation

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# General philosophy: combine machine with human

## MS comments

- In 2019 still, by far, a human being does much better with clients than a robot
- But a human supported by machines does it even better
- Machines are better for some tasks and humans for others

## Other banks

- JP Morgan: interaction between humans and AI is extremely important to us, this is how we develop everything
- Credit Suisse: digital solutions alongside high-end human expertise





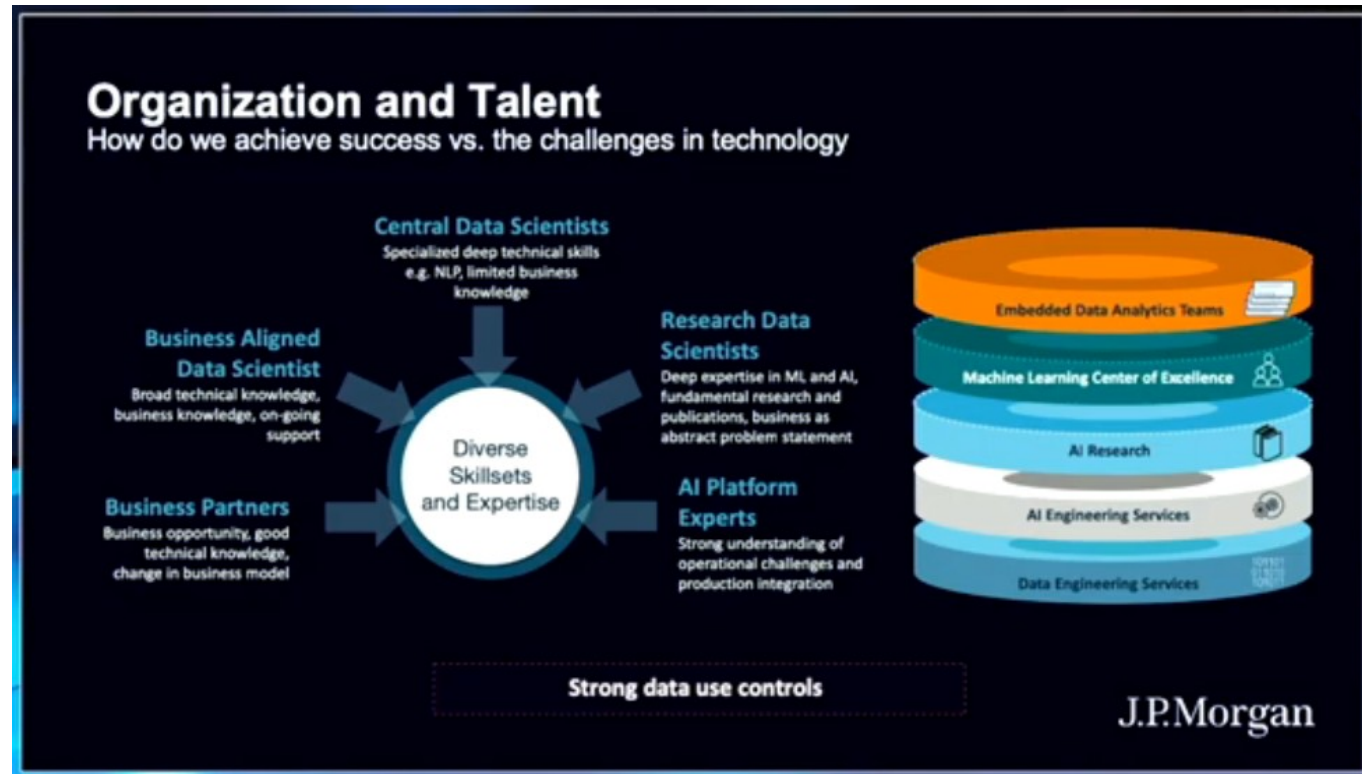
# JP Morgan: AI organisation

## JP Morgan comments

- Get embedded data scientists sitting next to business
- The ML Center of excellence helps them design and develop applications
- AI research team tries to solve hard problems, thinking long term
- Data engineering service is core and critical with everything that we do

## Other banks comments

- UBS: very active, fastest growing internal social media
- Credit Suisse ideation hub: creates forum where new opportunities and innovative ideas can be surfaced and explored



How do banks apply AI to Capital Markets?

ANNEXES: APPLICATION EXAMPLES

# Transactions data? What are we talking about?

## Transactions data

- Many types of transactions: closed sales, “Add to cart”, websites clicks on product page, asked questions, products ratings, ...
- Data easily represented the following way

Ope ID	Timestamp	Client ID	Product Ref	Quantit y
032 001	2020-04-13-09-34-56	FER_ES	FRYY_202006_S	34 200
032 002	2020-04-13-09-35-04	AIRB_EU	GERZ_202008_M	12 000
032 003	2020-04-13-09-35-47	FER_ES	FRYY_202006_S	85 620
032 004	2020-04-13-09-36-12	BT_UK	GERZ_202008_M	22 900
⋮	⋮	⋮	⋮	⋮

## As opposed to “content” data

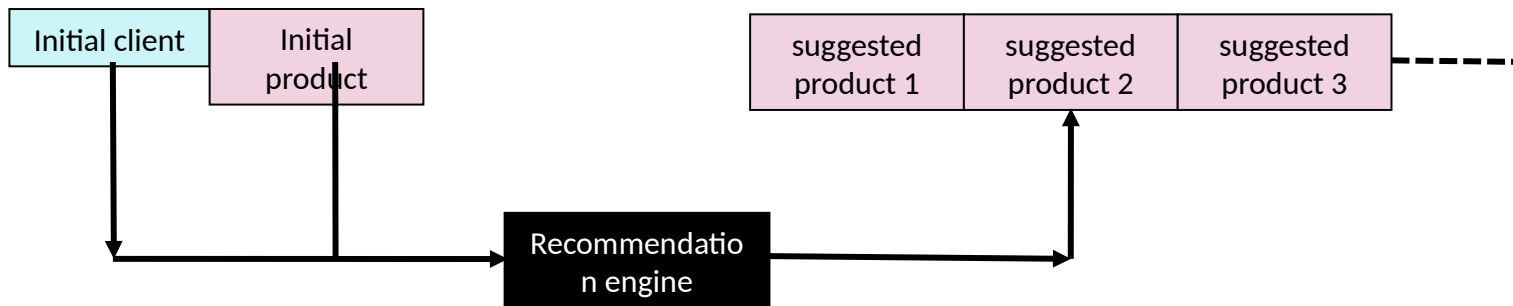
- Customers characteristics (= features):, address, age, nationality, incomes, height, weight, ...
- Products features: size, unit price, etc... Depends on your activity



# Applications 1 & 2

## Application 1 : recommendation engine

- “Amazon-like” or “Netflix-like” application
- Context: Initial transaction (closed deal, request for quote, add to basket, click, ...) of a client on a product
- Goal: suggest other product(s) that should trigger interest from initial client
- Potentially filtered using trading axes, or omitting obvious recommendations, etc...

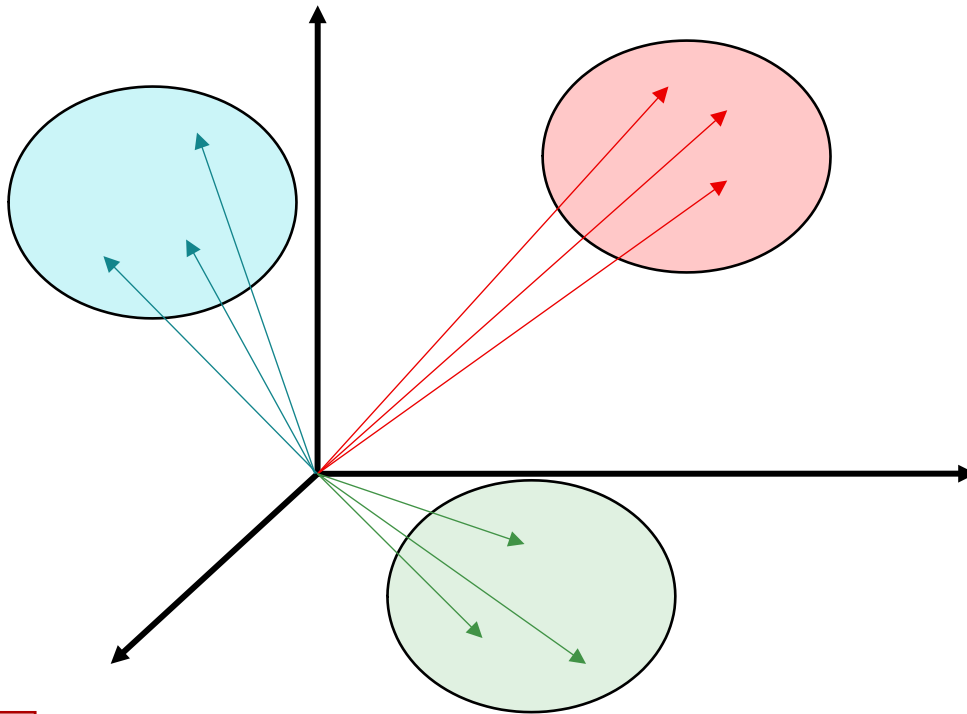


## Application 2: anomaly detection

- Singular client/product behavior. Identify customers with very high/small volumes on a particular product compared to other similar customers.
- The machine gives you insights, but you stay in command: you decide what to do with the results



## Application 3 : Customers and products segmentation



Applis

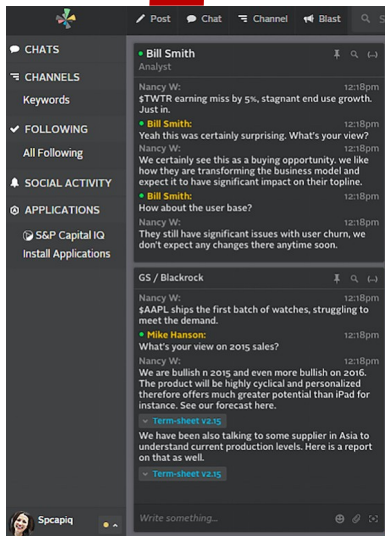
### Apply clustering algorithm

- Apply clustering algorithms separately to clients and to products
- Try to explain/interpret segments . Some classes will seem obvious. They help validating the algorithm accuracy
- Intermediate classes give more value: the algorithm detects relations that you would have never guessed they existed

### Exploit segments

- Test different actions on parts of different segments, based on initial interpretation
- Repeat and expand successful actions on whole segments
- Adjust interpretation
- Study segments stability over time, trying to explain jumps from one class to another

# Market quotes extraction from chats with brokers



Ope ID	Timestamp	Maturity	Bid	Offer
032 001	2020-04-13-09-34-56	10 y	0,931	0,933
032 002	2020-04-13-09-35-04	5 y	-	0,498
032 003	2020-04-13-09-35-47	7 y	0,692	0,695
032 004	2020-04-13-09-36-12	10 y	0,929	-

## Excellent results

- Using a combination of classic NLP (Natural Language Processing) and Machine Learning
- On EUR IRS, up to 99,97% accuracy

Applis



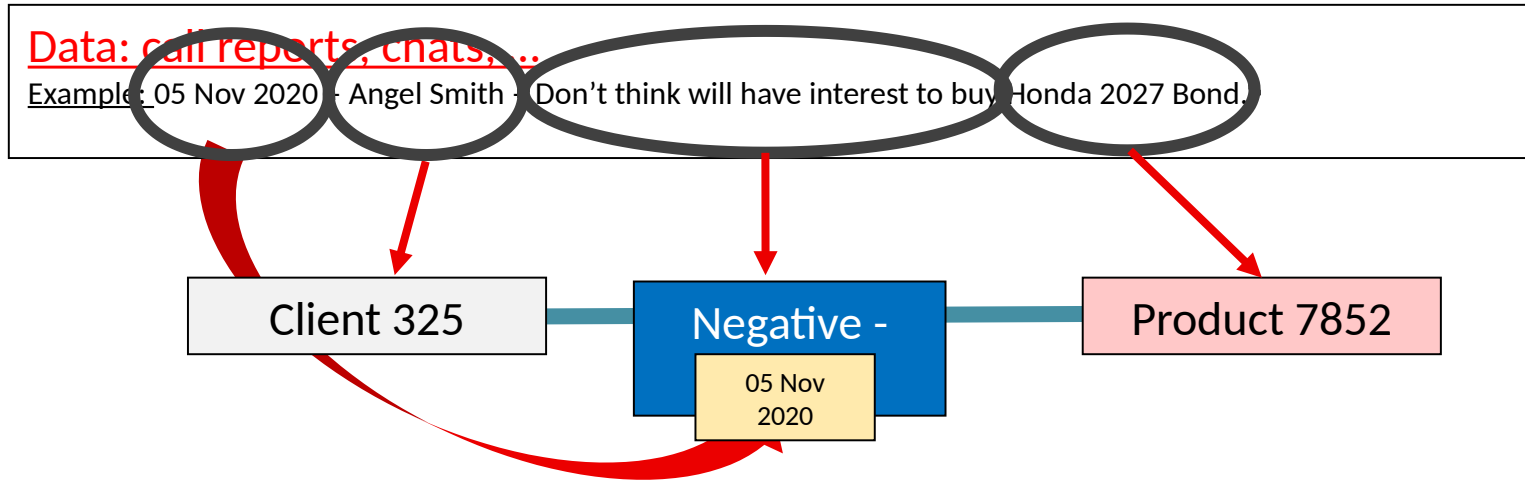
## Customer feedback exploitation

Data: call reports, chats, ...

Example: 05 Nov 2020 – Angel Smith – Don't think will have interest to buy Honda 2027 Bond.



## Customer feedback exploitation





# Customer feedback exploitation

Data: call reports, chats, ...

Example: 05 Nov 2020 - Angel Smith - Don't think will have interest to buy Honda 2027 Bond.

Client 325

Negative -

05 Nov  
2020

Product 7852

Clients details

Transactions data

Products taxonomy

News

Clients/products Knowledge  
graph

## Applications

- Database requests
- Clients segmentation, Products segmentations
- Recommendation engine
- Relations prediction
- ...

Applis

# Data quality check

#	Brand Value Statements (Benefits)	Importance MaxDiff										NF Performance MaxDiff															
		Total	Total Members (S1-4)	Total Prospects (S5-6)	S1: Millennial Members (18-34)	S2: Members (35-54)	S3: Members (55+)	S4: Members (Active Duty)	S5: Prospects	S6: Veterans	Member Female %	Member Male %	Prospect Female %	Prospect Male %	Total	Total Members (S1-4)	Total Prospects (S5-6)	S1: Millennial Members (18-34)	S2: Members (35-54)	S3: Members (55+)	S4: Members (Active Duty)	S5: Prospects	S6: Veterans	Member Female %	Member Male %	Prospect Female %	Prospect Male %
		1007	5419	278	189	687	566	178	153	329	529	800	57	221	1007	5419	278	189	687	566	178	153	329	529	800	57	221
1	Because they are a credit union, Navy Federal offers better options than an average bank.	134	130	157	126	163	127	70	138	181	133	128	145	159	131	128	146	95	143	149	75	143	148	126	128	128	150
2	As a credit union, nothing is more important to Navy Federal than serving their members.	107	110	89	81	105	123	108	85	94	101	116	78	92	118	122	100	104	109	146	109	90	113	122	121	99	100
3	As a credit union, Navy Federal puts my needs first.	75	74	79	81	66	76	76	76	81	69	77	70	80	70	70	73	77	72	64	65	60	92	69	70	67	74
4	I trust a credit union like Navy Federal more than a typical bank.	114	119	90	118	111	133	89	80	109	119	118	72	95	105	107	91	87	117	120	70	90	90	101	110	66	98
5	Navy Federal understands the unique needs of service members and their families.	66	66	66	56	58	57	146	84	49	55	73	64	67	99	100	93	108	100	79	171	90	95	86	108	148	82
6	Navy Federal offers products and services specifically designed for service members and their families.	64	64	63	64	64	51	177	76	50	52	72	49	67	101	102	94	109	101	81	177	118	70	91	108	117	88
7	I never worry about my finances because Navy Federal and I have a shared military background.	25	24	28	24	21	21	43	31	25	18	28	22	30	34	33	38	42	31	27	55	43	32	27	38	41	37
8	Navy Federal offers a wider range of products and services to meet my changing needs.	96	95	113	88	94	90	106	117	106	91	95	103	115	115	112	124	92	109	118	119	139	112	112	112	87	139
9	Navy Federal offers great rates and low fees.	276	269	309	247	337	229	244	313	306	273	266	391	291	231	205	244	187	230	193	185	227	264	191	212	270	236
10	Navy Federal offers no-cost banking products that save me money.	186	172	273	181	223	145	128	275	267	176	170	288	269	171	160	236	164	174	149	146	257	212	154	184	214	241
11	Navy Federal simplifies banking, making it easy and hassle-free.	125	128	108	144	123	133	99	114	101	124	129	113	107	123	126	108	175	127	121	89	98	120	126	125	75	118
12	Navy Federal is my financial partner; they offer me the right information, advice, and products to help me meet my needs.	89	88	92	109	75	85	99	88	97	91	86	90	93	77	75	91	90	71	65	94	89	92	80	71	105	87
13	Navy Federal is a leader in the financial industry with all the products and services needed.	58	55	71	42	48	67	49	67	76	57	54	80	69	71	70	75	62	66	77	55	71	61	78	65	83	73
14	Navy Federal is my partner; I know I get a good deal and they enable me to make the right decisions for my financial future.	70	69	69	80	65	64	80	63	76	78	65	67	60	64	64	61	77	59	57	66	56	67	69	61	74	58
15	Navy Federal has been there to keep me financially on top of my finances - for whatever life brings.	50	52	41	66	45	48	68	42	40	44	57	44	40	55	54	58	57	50	48	80	58	57	45	57	51	59
16	Navy Federal gives me confidence and control over my finances.	73	72	76	69	62	72	74	70	90	66	75	65	62	69	68	74	86	61	61	89	80	67	63	71	90	70
17	Navy Federal trusts me and works with me to achieve my goals.	42	42	44	50	41	37	47	45	41	39	44	35	45	42	40	49	53	36	36	52	48	49	36	42	49	48
18	Because Navy Federal shares my values, I can depend on them to operate with a high degree of integrity.	96	98	85	88	92	112	75	82	90	104	95	91	83	97	97	91	84	92	111	79	97	84	98	97	102	88
19	I have peace of mind knowing me and my money are safe with Navy Federal.	113	117	95	132	91	134	114	95	93	135	107	110	91	118	123	92	115	108	137	125	88	97	133	117	72	97
20	Navy Federal is available whenever I need, 24/7/365.	133	143	90	159	137	133	145	85	95	156	136	99	88	122	131	85	127	139	118	140	77	94	141	124	101	80
21	The ability to always speak with a real person sets Navy Federal apart.	118	124	80	100	107	149	115	94	82	132	120	69	94	107	112	81	105	104	127	95	87	74	129	103	59	88
22	Navy Federal offers unbiased and helpful advice.	37	36	40	38	37	36	29	45	34	35	37	34	41	47	45	51	49	45	45	36	57	45	45	45	54	50
23	Navy Federal takes the time to answer questions and work through decisions.	96	96	93	98	85	107	80	94	90	100	93	90	93	93	92	96	90	89	94	88	91	102	100	88	111	92
24	Navy Federal is committed to delivering a high level of service.	135	137	138	138	180	171	120	142	132	152	140	129	140	162	165	148	165	146	175	124	147	143	169	162	138	147
25	95% of all survey responses Top Tier if 5 or more Bottom Tier if 4 or less	110	115	124	129	118	116	130	133	139	119	113	160	127	109	110	121	129	117	116	130	139	139	117	112	150	126
26		109	110	124	129	118	116	130	133	139	119	113	160	127	109	110	121	129	117	116	130	139	139	117	112	150	126
27		92	91	81	87	85	85	77	75	73	85	80	62	79	82	81	81	78	85	86	77	75	73	86	69	63	79



# Data quality check

## Version 1 : replicate teams results

- M/O or risk teams currently working on checking data quality, identifying wrong data
- Train Machine Learning algorithms to replicate their results
- Already in production for daily CVA/DVA deal filters

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1	Because they are a credit union, Navy Federal offers better options than an internet bank...	134	130	157	126	163	127	70	138	181	133	128	145	159	131	128	146	95	143	149	75	143	148	126	128	128	150
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4	I trust a credit union like Navy Federal more than a typical bank.	114	119	90	118	111	133	89	80	80	119	118	72	95	105	107	91	87	117	120	70	90	90	101	110	65	98
5	Navy Federal understands the unique needs of service members and their families.	96	98	65	56	58	57	146	84	49	55	73	64	67	99	100	93	108	100	79	171	90	95	86	108	146	82
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13	Navy Federal is a leader in the financial industry with all the products and services needed.	58	55	71	42	48	67	49	67	76	57	54	80	69	71	70	75	62	66	77	55	71	81	78	65	83	73
14	Navy Federal is my safe place; I know I get a good deal and they enable me to make smart decisions for my financial future.	70	69	69	80	65	64	80	63	76	78	65	67	60	64	64	61	77	59	57	66	56	67	69	61	74	58
15	Navy Federal has been there to keep me firmly in command of my finances - for whatever the brings.	50	52	41	66	45	48	68	42	40	44	57	44	40	55	54	58	57	50	48	60	58	57	45	57	51	59
16	Navy Federal gives me confidence and control over my finances.	73	72	79	89	62	72	74	70	90	66	75	65	82	69	68	74	86	61	61	89	80	67	63	71	90	70
17	Navy Federal trusts me and works with me to achieve my goals.	42	42	44	50	41	37	47	45	41	39	44	35	45	42	40	49	53	36	36	52	48	49	38	42	49	48
18	Because Navy Federal shares my values, I can depend on them to operate with a high degree of integrity.	96	98	85	88	92	112	75	82	90	104	95	91	83	97	97	91	84	92	111	79	97	84	98	97	102	88
19	I have peace of mind knowing me and my money are safe with Navy Federal.	113	117	108	132	91	134	114	95	93	135	107	110	91	118	123	92	115	108	137	125	88	97	133	117	72	97
20	Navy Federal is available whenever I need, 24/7/365.	133	143	90	159	137	133	145	85	95	136	136	99	86	122	131	85	127	139	118	140	77	94	124	124	101	80
21	The ability to always speak with a real person sets Navy Federal apart.	118	124	107	100	107	149	115	94	82	132	120	69	94	107	112	81	105	104	127	95	87	74	129	103	59	88
22	Navy Federal offers unbiased and helpful advice.	37	36	40	38	37	36	29	45	34	35	37	34	41	47	45	51	49	45	45	36	57	45	45	54	50	50
23	Navy Federal takes the time to answer questions and work through decisions.	96	96	93	98	85	107	80	94	90	100	93	90	93	93	92	96	90	89	94	88	91	102	100	88	111	92
24	Navy Federal is committed to delivering a high level of service.	135	137	138	138	180	171	120	142	132	152	140	129	140	142	145	148	145	146	175	124	147	143	149	142	138	147
25	95% CS within segments	108	110	114	118	118	116	120	133	137	117	113	140	127	109	110	123	129	117	116	130	130	137	117	112	150	126
26	Top Tier if > 30%	108	110	114	118	118	116	120	133	137	117	113	140	127	109	110	123	129	117	116	130	130	137	117	112	150	126
27	Bottom Tier if < 30%	92	91	87	97	85	96	77	75	73	85	80	82	79	82	91	81	71	85	86	77	75	73	80	89	80	79

## Version 2:

- Typical "anomaly detection" problem
- Algorithm learns directly from data the mainstream data structure, mainstream behavior
- => identifies strange data, strange behavior.

# Market data historical series

## Extract main factors

- Using Variational AutoEncoders technique, an extension of Principal Component Analysis to non-linear complex relations
- Typically reduces swaption vol cubes from 9 000 data to 250 factors, vol surfaces from 500 data to 25 factors, Interest rates curves from 20 data to 2 factors

## Applications

- Build scenarios controlling probability distributions (quantiles, ...)
- Data quality check, anomaly detection
- Guess missing or wrong historical data
- Imply non-liquid data from more liquid data (US IR curve, main FX pairs, ...)

Applis

