On Transaction-Based Metrics as a Proxy for Profitability of Financial Asset Recommendations

Javier Sanz-Cruzado

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Recommender systems

Item features

Items

User profiles   Users   Rating matrix
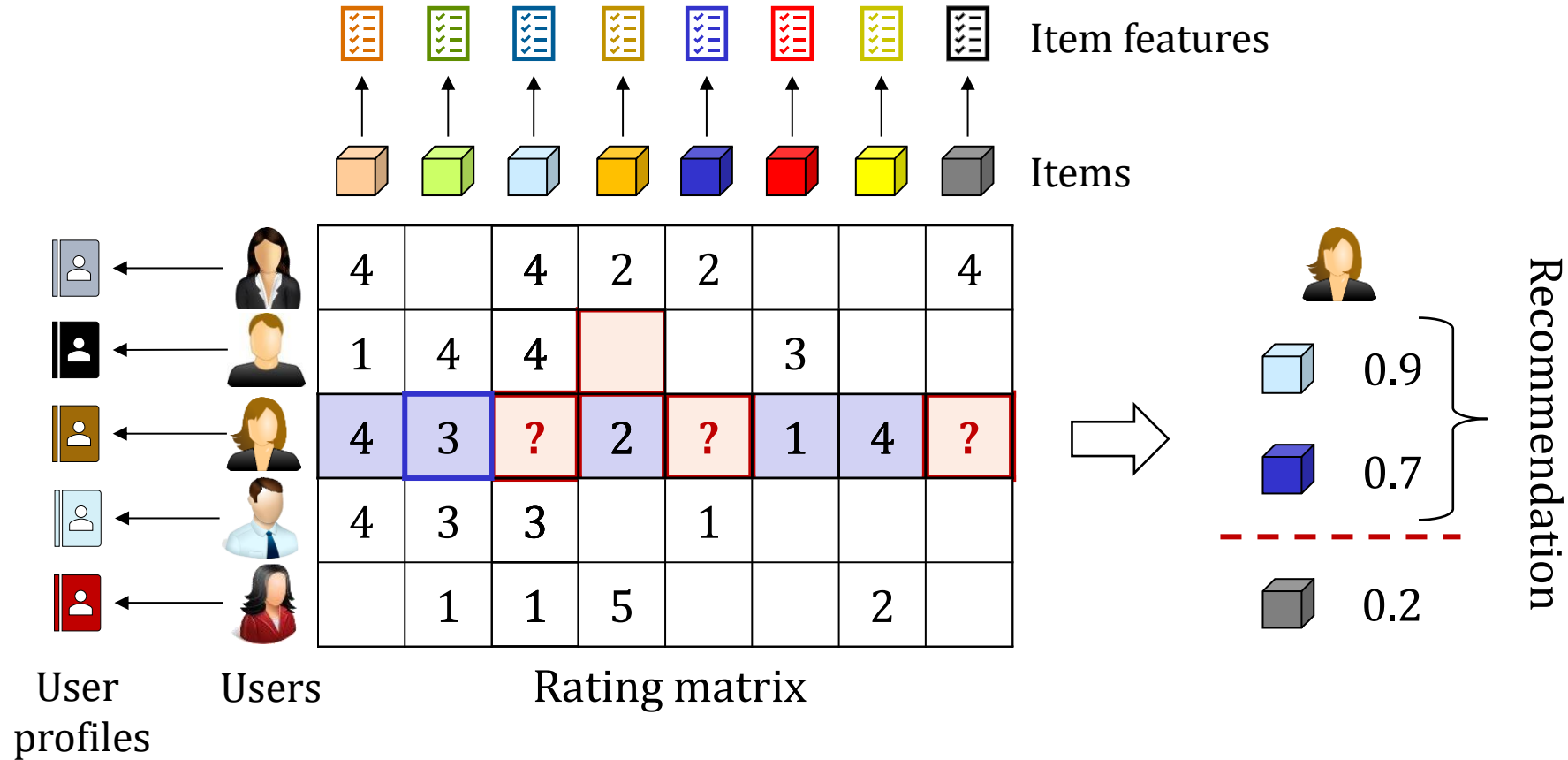
Recommendation

Recommender systems applications

Movies/TV series: Netflix, Disney+, Amazon Prime Video, BBC iPlayer,…

Music (Songs, artists, CDs): Spotify, Deezer, Pandora, Amazon Music,…

Books: Goodreads

Shopping: Amazon, eBay…

People: LinkedIn (jobs), Twitter, Facebook, TikTok (friends / followees)

Financial assets **OUR FOCUS**

Before continuing... a small survey

Please raise your hand if (a) you are familiar with, (b) you've heard about it but you are not sure you know what it is:

All these questions are related to the financial domain

- The difference between real and financial assets.

- The definition of equity.

- The definition of a corporate / government bond.

- The definition of mutual fund.

- The definition of option.

- The definition of futures contract.

Real vs. financial assets

Real assets	Assets	Financial assets

Real assets

- Used by companies to generate goods and services.

- Value depends on substance and properties of the assets

- Examples:
  – Real estate: lands, buildings
  – Commodities (natural resources): oil, gas, gold,…
  – Infrastructure: vehicles, computers
  – Intangible (IP): patents, licenses, …

Financial assets

- Determine how the ownership of real assets is distributed among investors.

- Value depends on contractual rights or ownership claims.
- Value reflects factors of supply and demand **(changes over time)**

- Examples:
 – Corporate bonds
  – Stock

Types of financial assets

- **Fixed-income or debt securities**
  - Promise a stream of income determined by a specified formula.
  - Ex: corporate / government bonds.

- **Equity (or common stock)**
  - Represent an ownership share of a firm.

- **Derivative securities**
  - Provide payoffs depending on prices of other assets.
  - Ex: options and futures contracts.

- **Mutual funds**
  - Provided by investing companies.
  - Ownership of part of the company investment portfolio.

Financial asset recommendation (FAR)

- **Goal:** help our customers earn money

- **Items:** financial assets

- **Item features:**
  - Basic information
  - Reviews (news, social media)

  +

Value time series
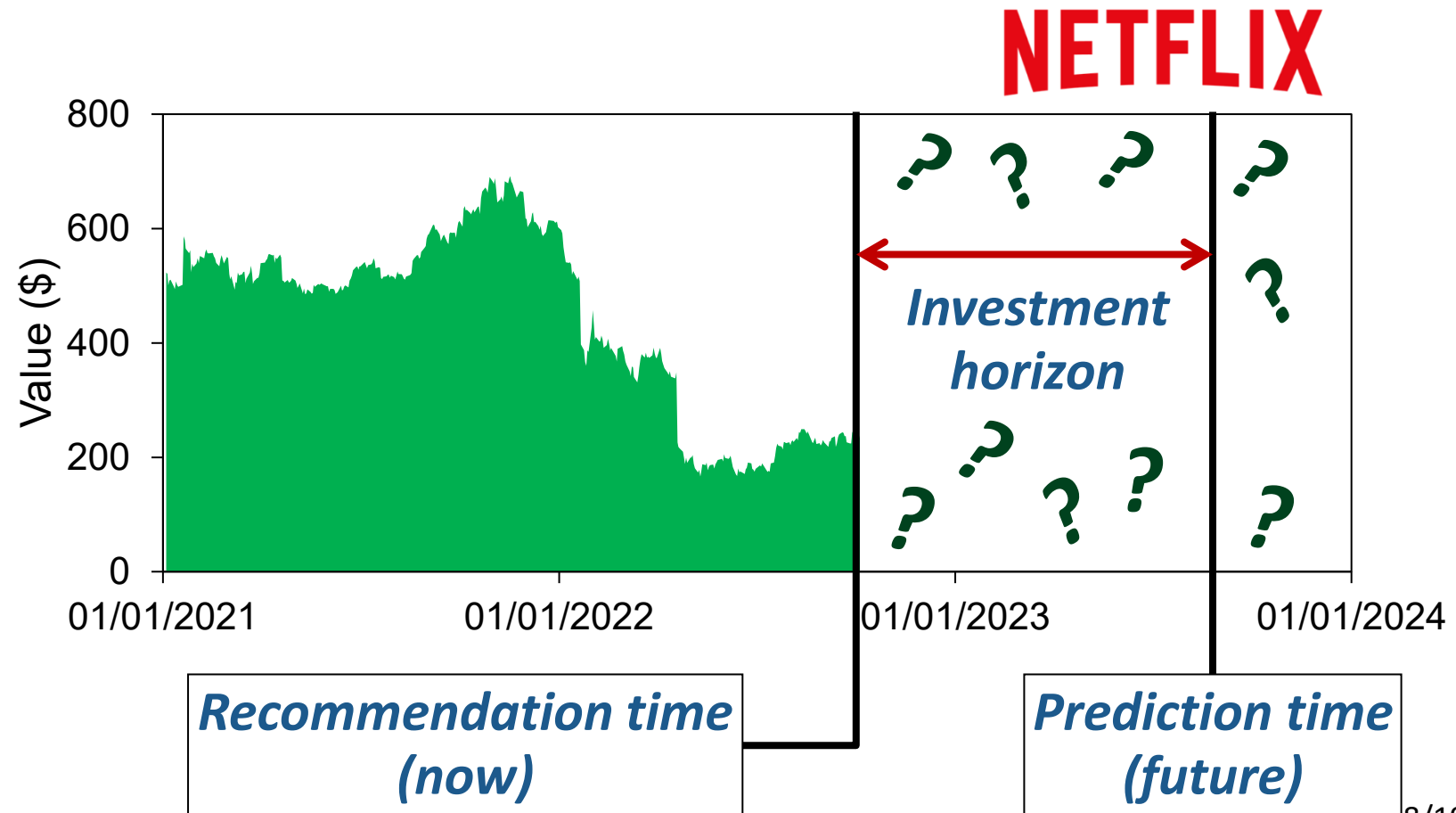
Why financial asset recommendation (FAR)?

1. **Digital transformation of financial services.**

2. **Simplification of the access to investments**

3. **Growing pool of financial assets, sources of information, etc.**

Digital transformation of financial services

- Home banking services started in the 1980s
  - **US:** United American Bank, 1980
  - **UK:** Bank of Scotland, 1983 (Homelink)
  - **France:** CCF Bank, 1983

- Most banks offer online services now
  - Web apps
  - Mobile phone apps
  - 80% banks provided online banking services in the US by 2000.

- **Extreme case:** digital-only banks
  - Examples: Starling bank, Revolut, Monzo
  - 27% of the UK population has a bank account on them (as of 2021)
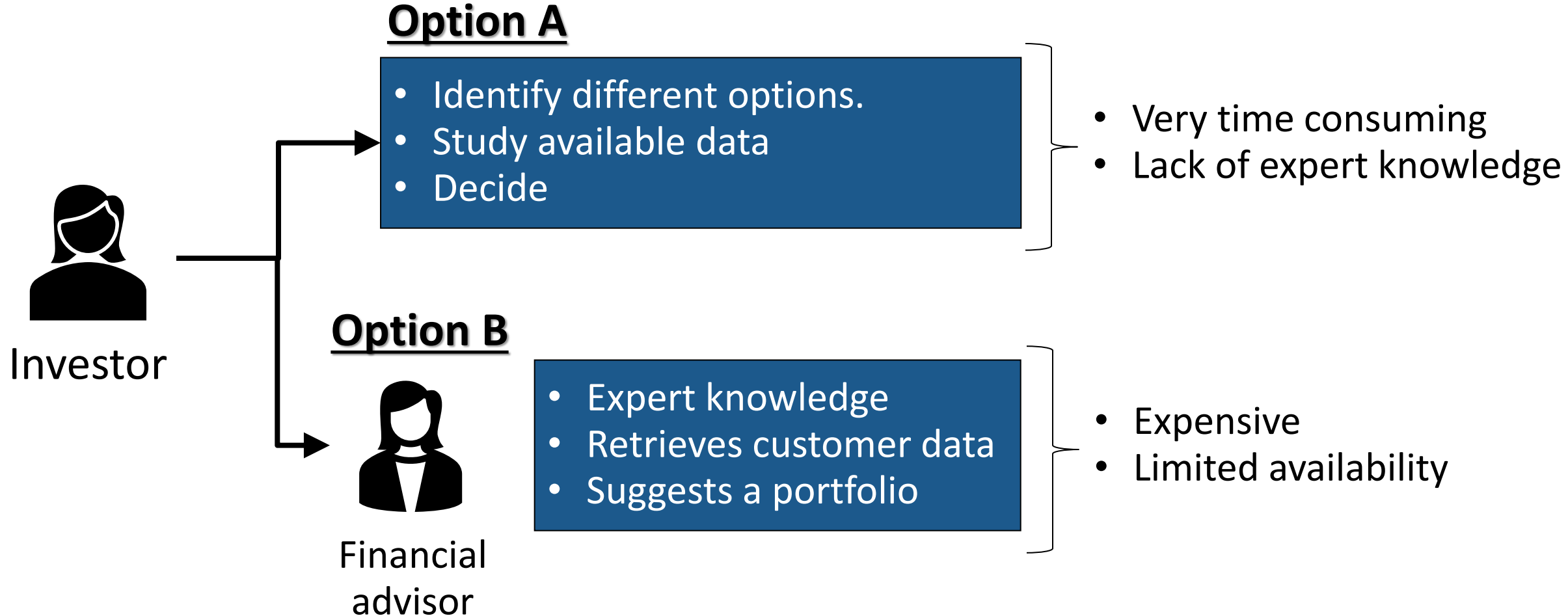
Usage of online banking in the UK
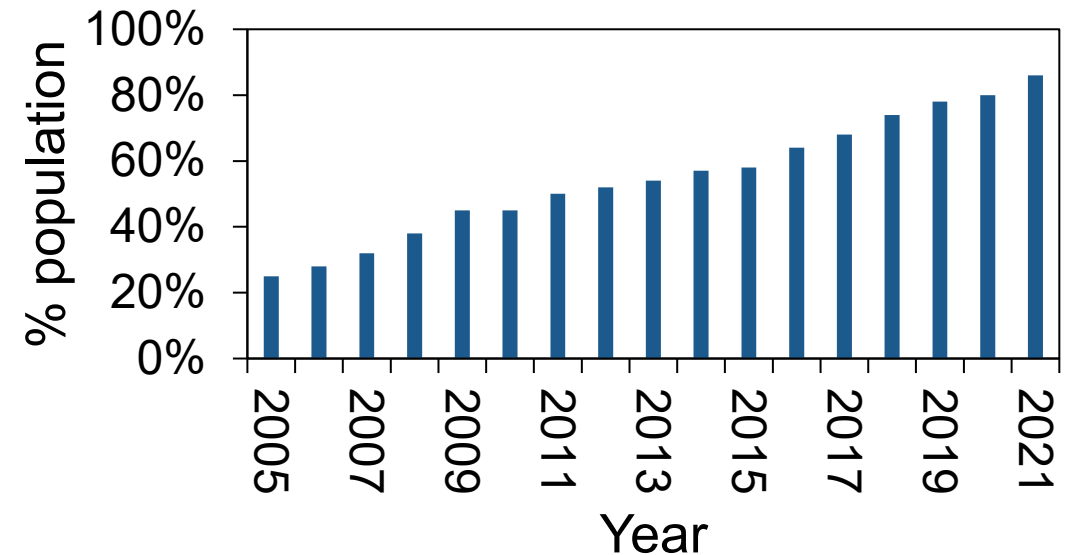
FAR can be one more of the online financial services!

Simplification of access to investments

Not so long ago…

Option A

Investor

- Identify different options.
- Study available data
- Decide

- Very time consuming
- Lack of expert knowledge

Option B

Financial advisor

- Expert knowledge
- Retrieves customer data
- Suggests a portfolio

- Expensive
- Limited availability

Simplification of access to investments (II)

Option C: Robo-advisors

- Employ algorithms to provide financial advice

- Minimum human intervention.

- Obtain information from investors from questionnaires.

- Examples: Wealthfront, Betterment

- Advantages:
  – Less expensive (lower fees)
  – More availability (24/7)

- Disadvantages
  – Limited flexibility
  – Limited personalization

Robo advisors are a growing market:

Assets under management of
robo-advisors (worldwide)
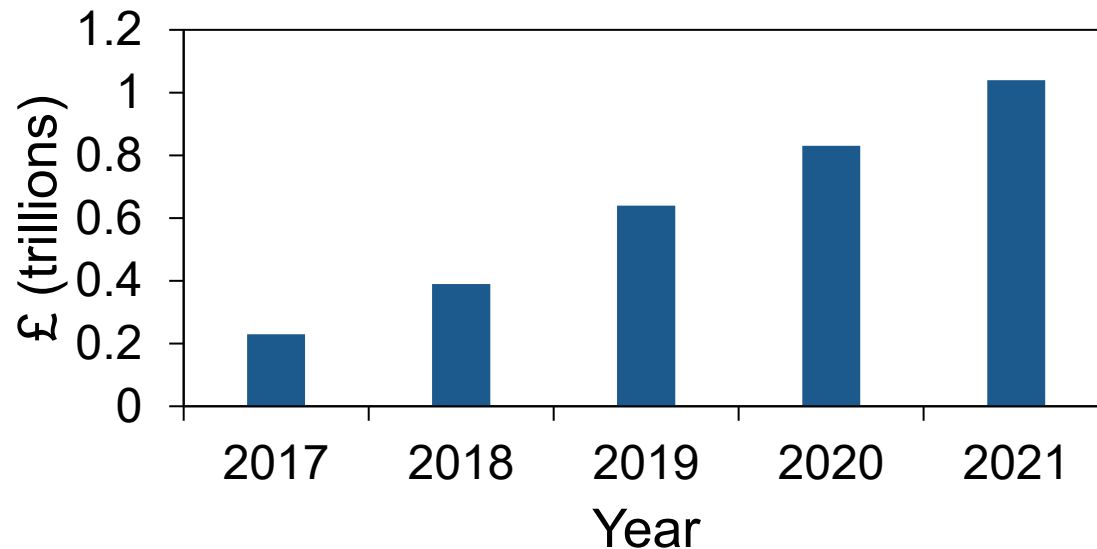
Financial asset recommendation can be used by robo-advisors to identify (personalized!) assets

Even projected to £2.2 trillion in 2027!

Growing pool of data / assets

Let's look at the stock market
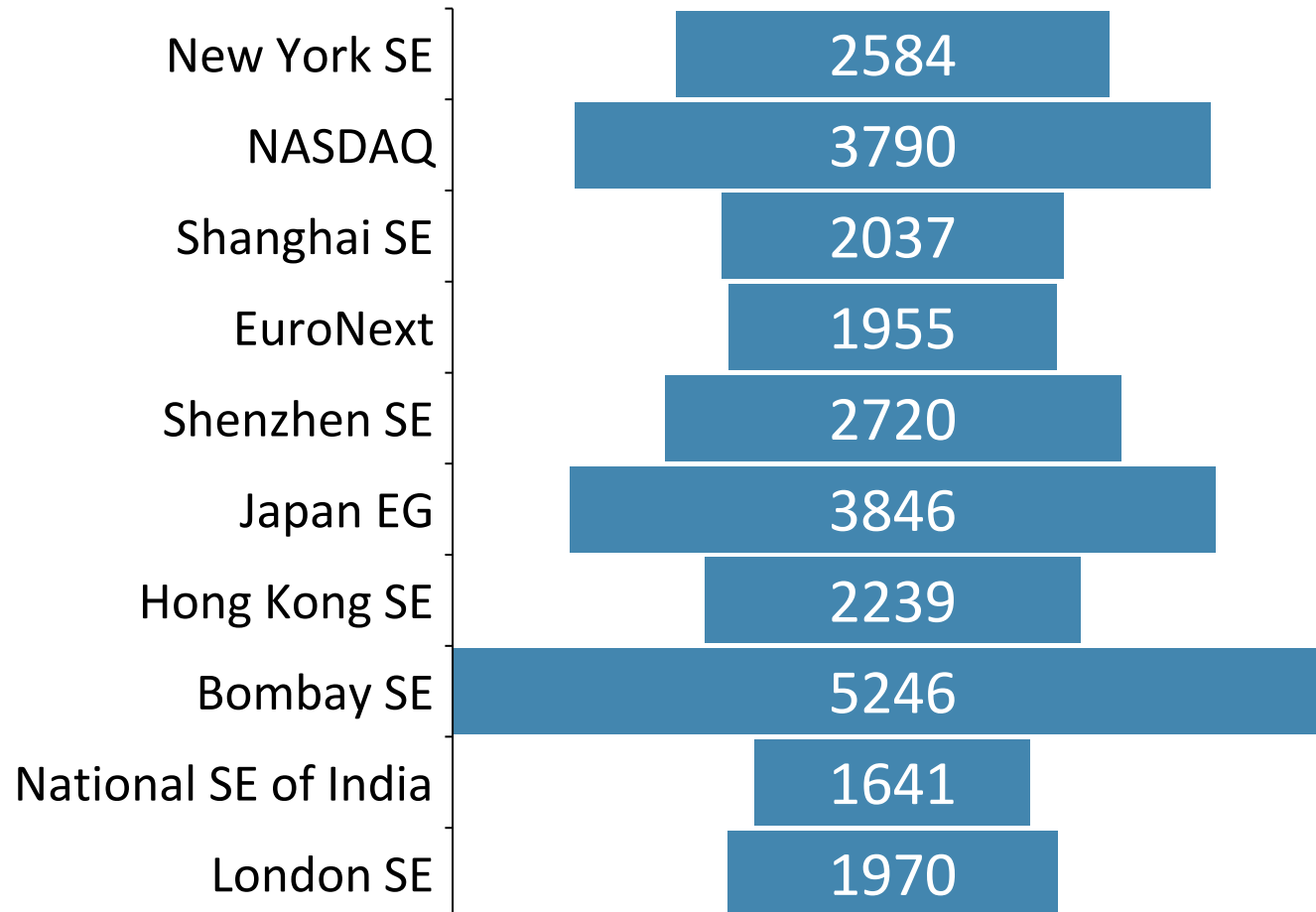
Number of listed companies

Exchange	Number
New York SE	2584
NASDAQ	3790
Shanghai SE	2037
EuroNext	1955
Shenzhen SE	2720
Japan EG	3846
Hong Kong SE	2239
Bombay SE	5246
National SE of India	1641
London SE	1970

Chart only considers stocks…

But what about:
- Government / company bonds
- Derivatives
- Mutual funds
- …

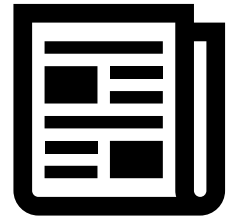# Growing pool of data / assets (II)
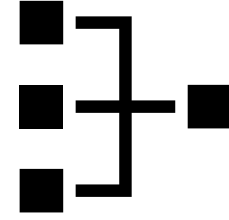
Sources of information
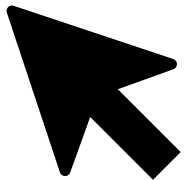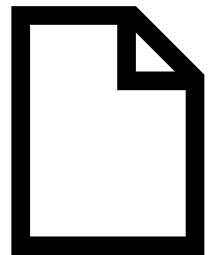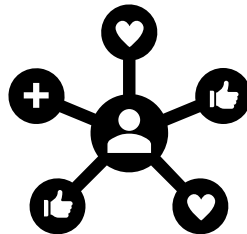
Time series
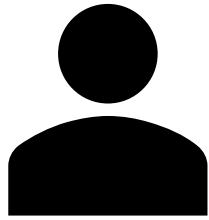
Customer profile

News

Knowledge graphs

...and more

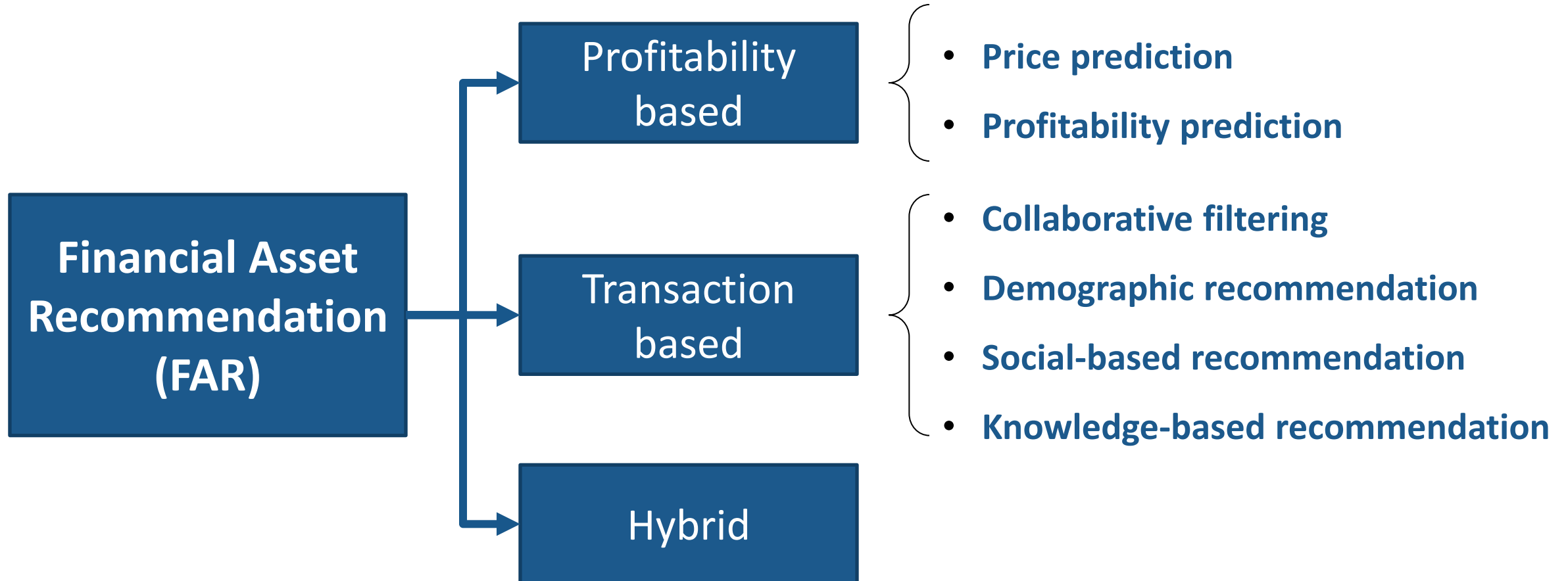Customer interactions

Asset information

Social media

Expert opinions

Algorithms

Financial Asset Recommendation (FAR)

→ **Profitability based**
- **Price prediction**
- **Profitability prediction**

→ **Transaction based**
- **Collaborative filtering**
- **Demographic recommendation**
- **Social-based recommendation**
- **Knowledge-based recommendation**

→ **Hybrid**

Cost of failing recommendations

Recommended item	Time cost	Money cost	
Song	1-3 minutes	0-20£	
Movie	1.5-3 hours	0-30£	Costs mostly in time and trust on the system
Book	2-20 hours	0-50£	
TV series	8-120 hours	0-200£	
Videogame	2 hours (min)	0-100£	
Financial asset	???	**How much did you invest?**	

Evaluation

| **Profitability / Performance** | ← | **Financial Asset Recommendation** | → | **Transaction-based** |

Do our customers earn money?

- Aligned with customer interests.
- Ignores customers actual investments.

Can we predict future investments?

- Investment transactions indicate strong preference.
- Relevant transactions: acquisitions.
- Ignores temporal pricing information.

In both cases, metrics look at a fixed time interval

- **Metrics:** Key performance indicators
  - Return on Investment (ROI)
  - Net profit

- **Metrics:** IR / RecSys metrics
  - Precision
  - nDCG

On transaction-based metrics

If customers invest intelligently

- Expected high correlation between transaction-based and profitability metrics.
- In that case, transaction-based metrics should be superior.

   ➡️ They consider customer preferences

But, is that the case?

RQ1. Can we indistinctively use transaction-based and profitability-based metrics for evaluating financial asset recommendations?
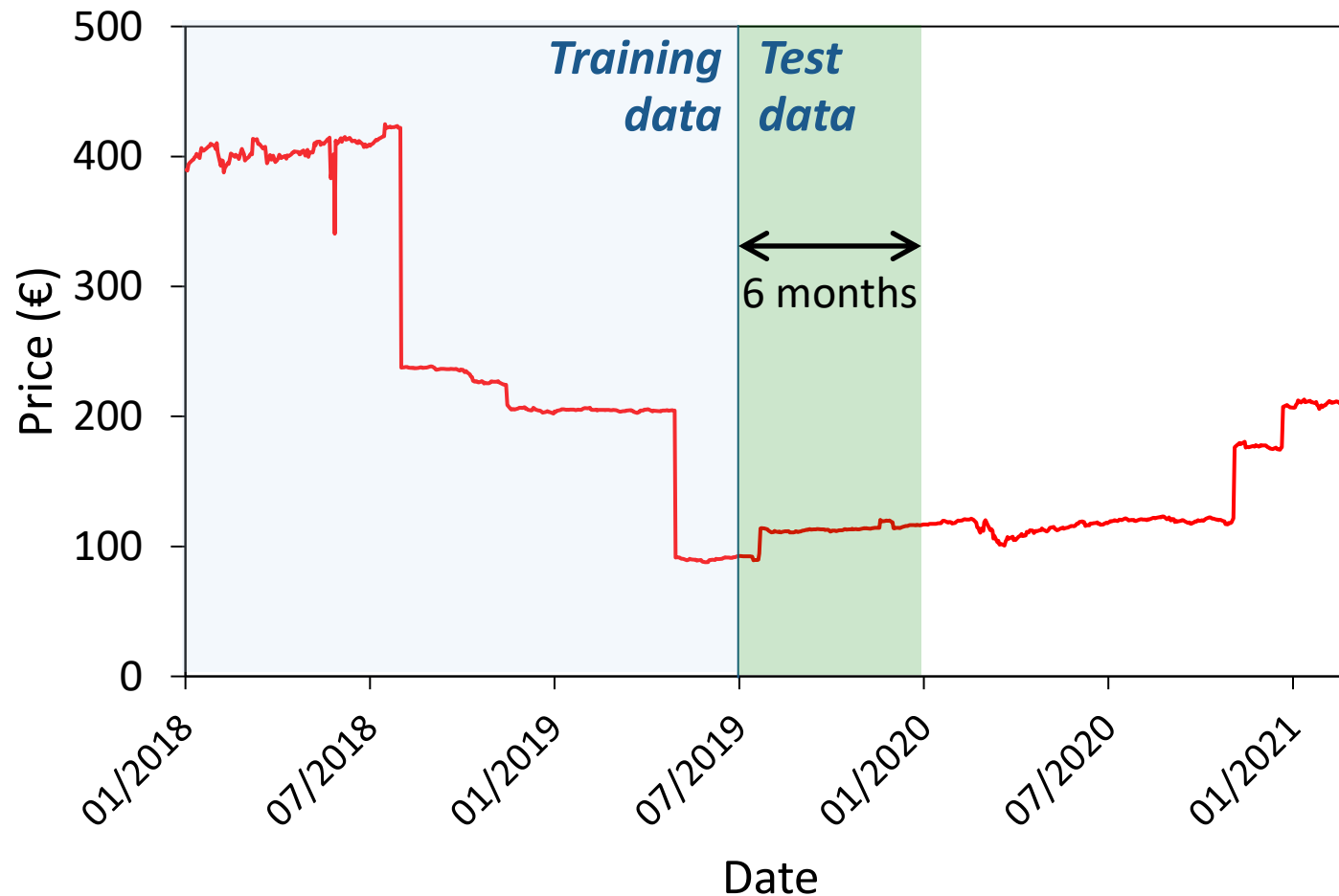
Dataset

- **Greek market:** stock, bonds, mutual funds and other banking products

- **Period:** 1st January 2018 – 21st March 2021

- **Combines**

  - Time series data (pricing information)

  - Customer investments

- **Time series data:**

  - 5,371 financial assets (2,025 assets with investments)

  - 1,768,128 data points

- **Customer investments**

  - 52,390 customers

  - 313,004 transactions

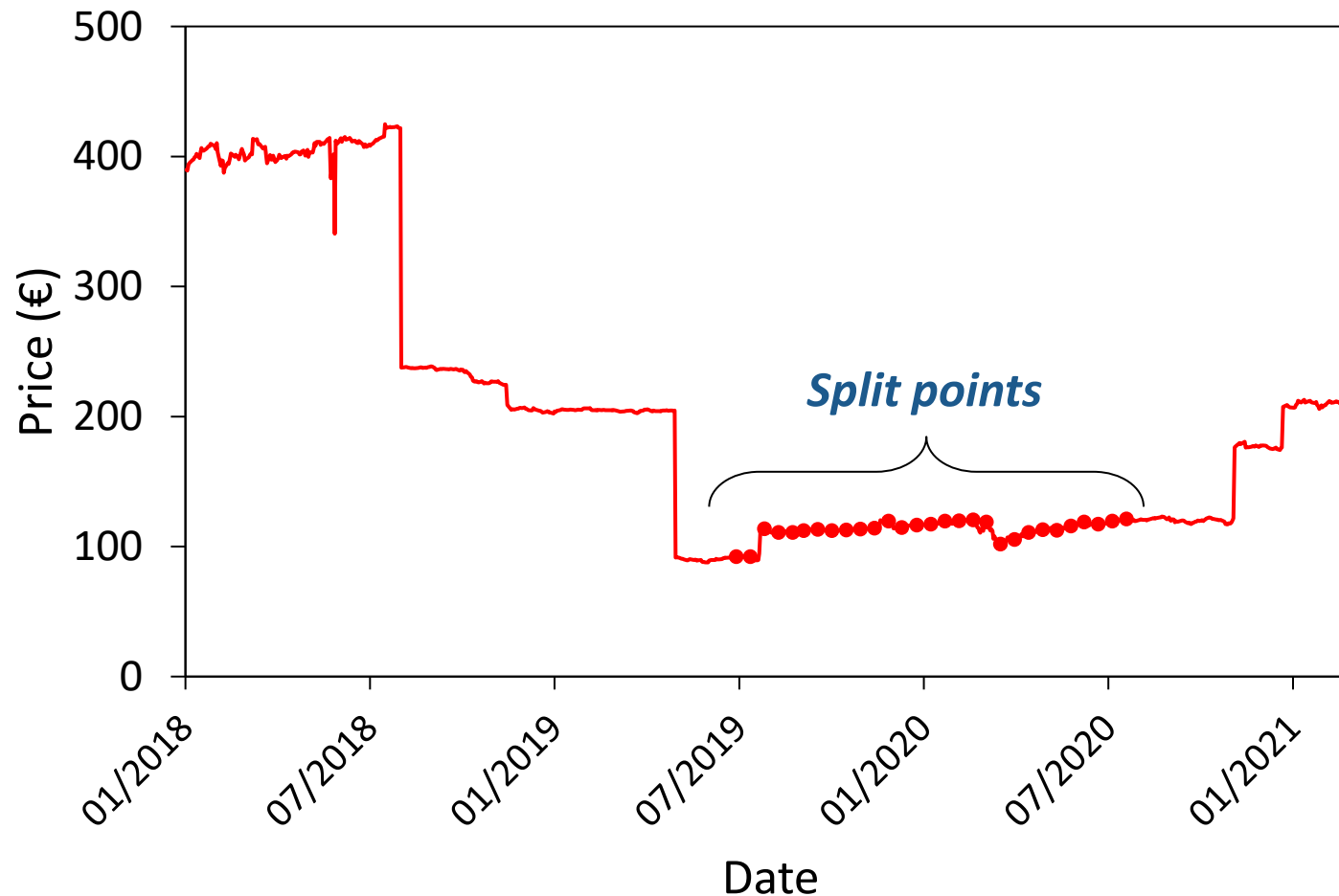# *Experimental procedure*

Avg. Pricing data

Procedure
1. Select recommendation time t
2. Split into training / test
   - **Training:** From 1st Jan 2018 to t
   - **Test:** From t to $t + 6$ months
3. Train models
4. Execute recommendations at t
5. Evaluate

Experimental procedure

Avg. Pricing data

Split points

Price (€) — Date

Procedure
1. Select recommendation time t
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29 split points
- One every two weeks
- From: 1st July 2019
- To: 22nd July 2020

Metrics

Profitability-based: return on investment (ROI@10)

- Relative increase w.r.t. the initial investment after some time Δt

- **Initial price:** price at recommendation time

- **Final price:** price at recommendation time + Δt

- Δt: six months

Transaction-based: nDCG@10

- Higher nDCG indicates our model predicts future customer investments.

- Ranking-based IR/RecSys evaluation metric

- Relevant transactions:

  – Asset acquisitions (buys)

  – Up to 6 months after recommendation

Algorithms

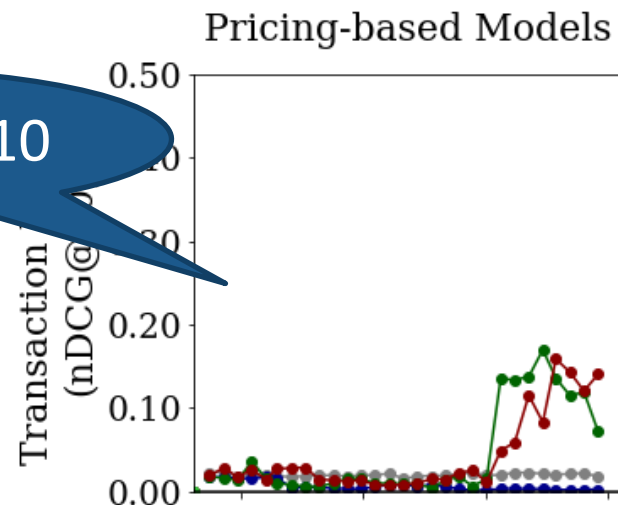## Profitability-based regression models

- Support vector regression (SVR)

- Random forest

- LightGBM
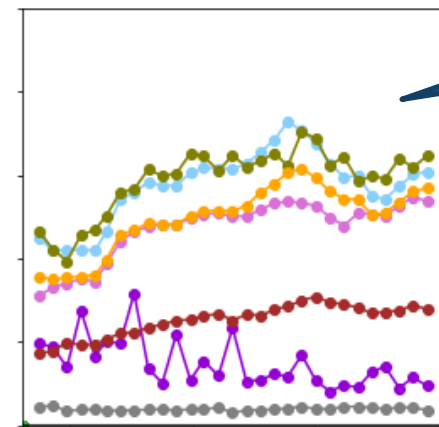
Transaction-based models

- **Not personalized:** popularity-based, random

- **Collaborative filtering:** LightGCN, MF, UB kNN, association rule mining

- **Demographic methods:** UB kNN with customer information

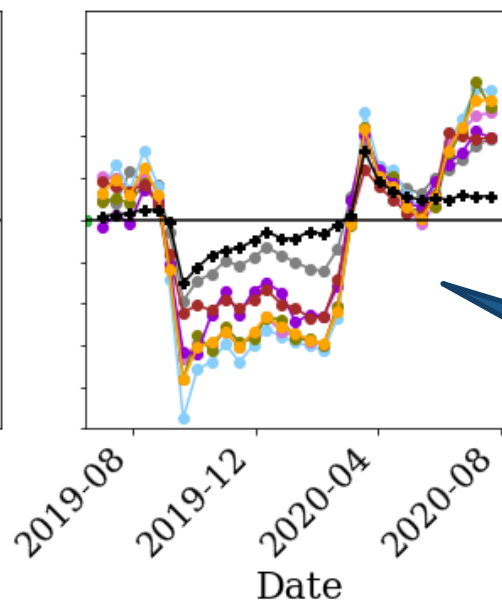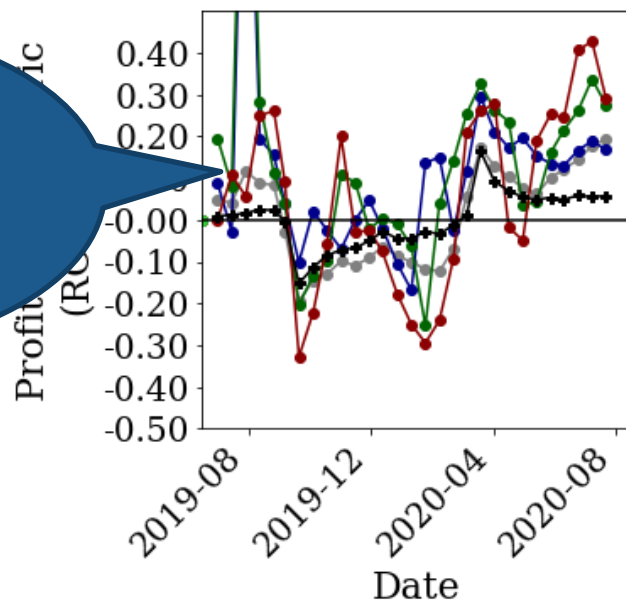# RQ1. Can we exchange transaction-based and profitability-based metrics?

RQ1. Can we exchange transaction-based and profitability-based metrics?

- We observe many differences between nDCG and ROI.

- But… are they even correlated?

- We take:

  - Average metric values (ROI@10 / nDCG@10) for each algorithm / split point

  - Compute Pearson correlation between both metrics

- Result: **-0.22**!

- Increasing nDCG $\Rightarrow$ money losses!

CONCLUSION: We cannot exchange both metrics. But why?

RQ2. What are the main factors that influence transaction-based metrics?

RQ2. What are the main factors that influence transaction-based metrics?

We consider three factors:

- Effectiveness of the customers

  - Do our customers invest well?

- Market changes

  - Pandemics, wars, economic crises, etc. affect market prices

  - Example: Covid-19 sank the markets

- Customer strategy

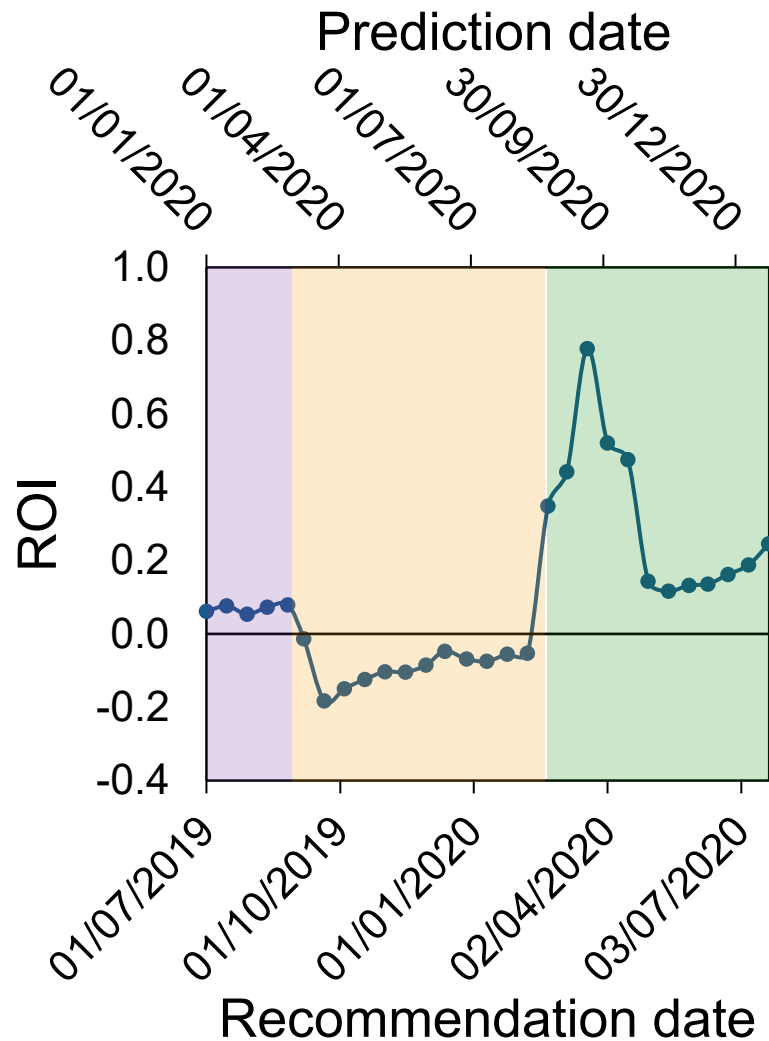 - How much time do customers hold assets?

Effectiveness of the customers

- If customers invest intelligently, we would expect positive correlation

- Are customers losing money?

Legend: Assets (market) · Customers
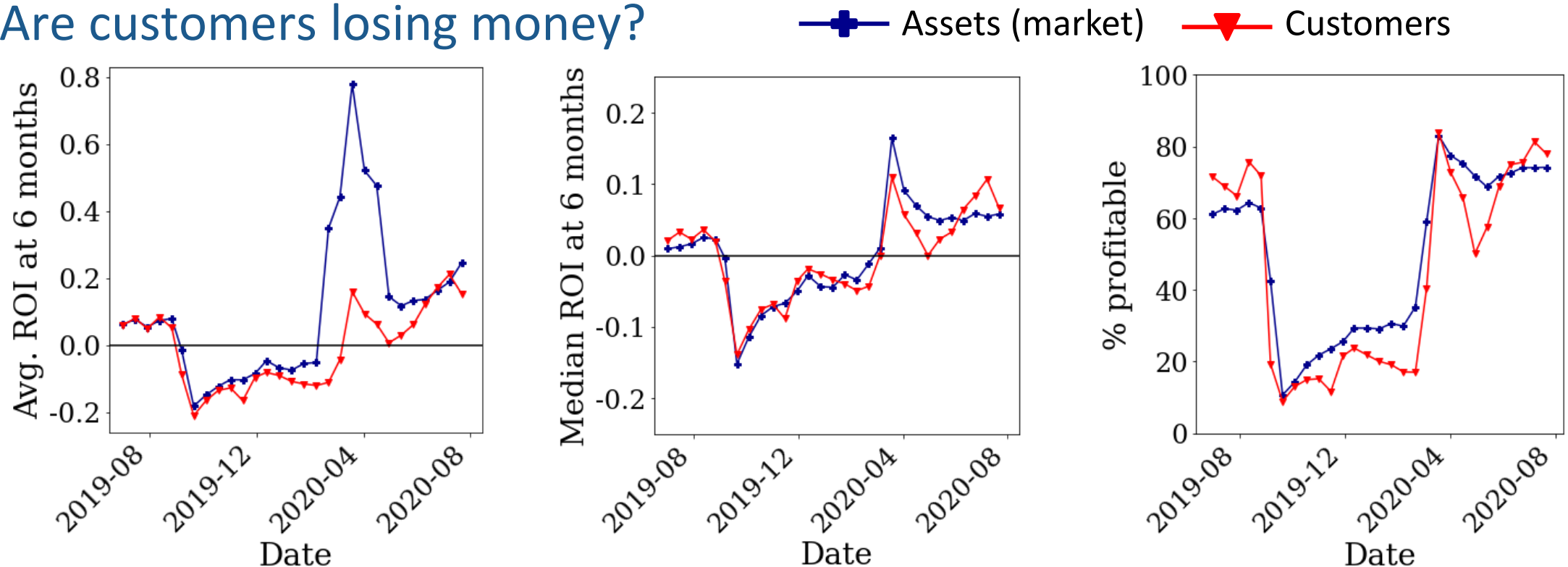
- Customers in our dataset are not particularly good investors.

- This explains lack of correlation between ROI and nDCG

Market changes

- We observe our profitability at 6 months
- Changes in asset profitability over time

- *PERIOD 1:* January 2020 – March 2020
  - Normal period
  - Market growth (slow)

- *PERIOD 2:* March 2020 – September 2020
  - Great loss period
  - Impact of Covid-19 pandemic

- *PERIOD 3:* September 2020 – January 2021
  - Recovery period
  - Great market growth

Market changes (II)

Prediction date

Recommendation date
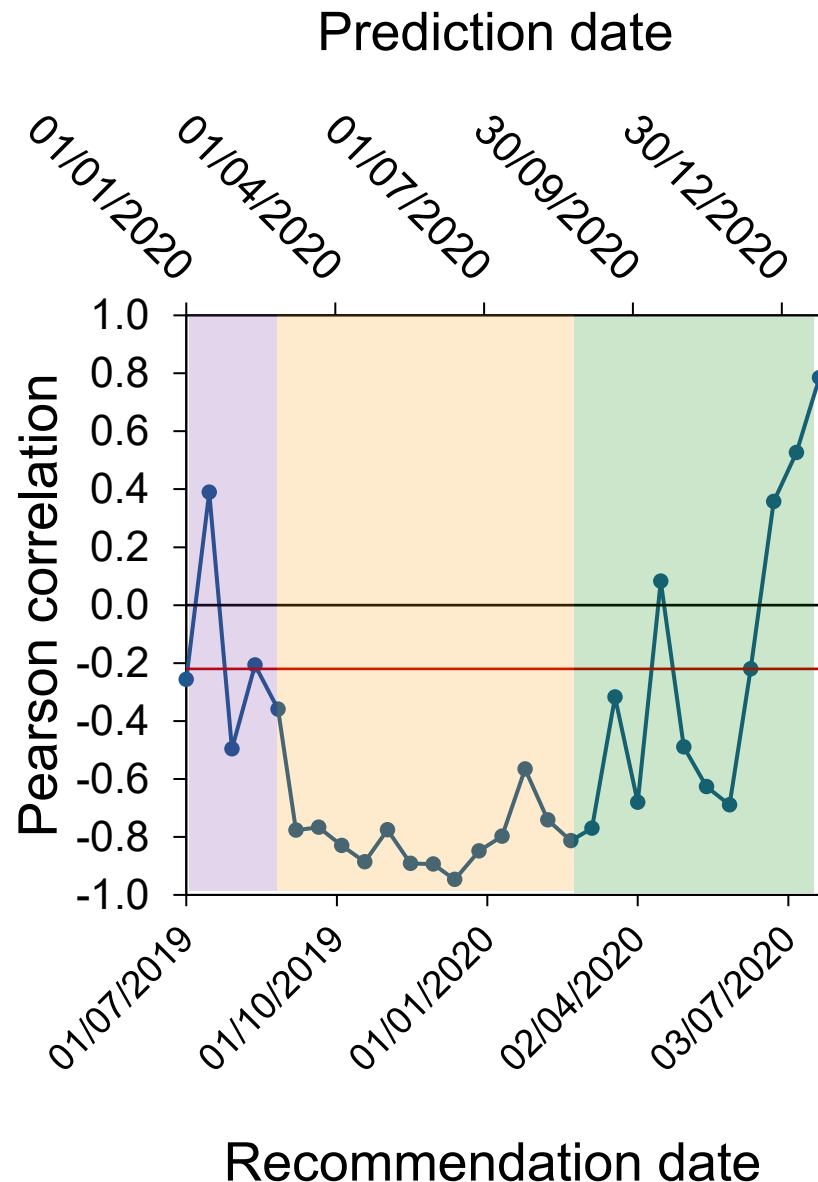
Do these changes affect the correlation between the metrics?

- Correlation between nDCG and ROI at every recommendation point
- Red line: overall correlation (-0.22)

- *PERIOD 1:* Positive to mildly negative correlation (Between -0.5 and 0.5)
- *PERIOD 2:* Very negative correlation (< -0.7)
- *PERIOD 3:*
  - Slow growth of Pearson correlation
  - Ends in high correlation (around 0.7)

- Market conditions affect correlation

Customer strategy

Is six months a reasonable future time target?

- We analyze how long people hold their investments (on average)

Only around 22% hold their investments for less than 7 months
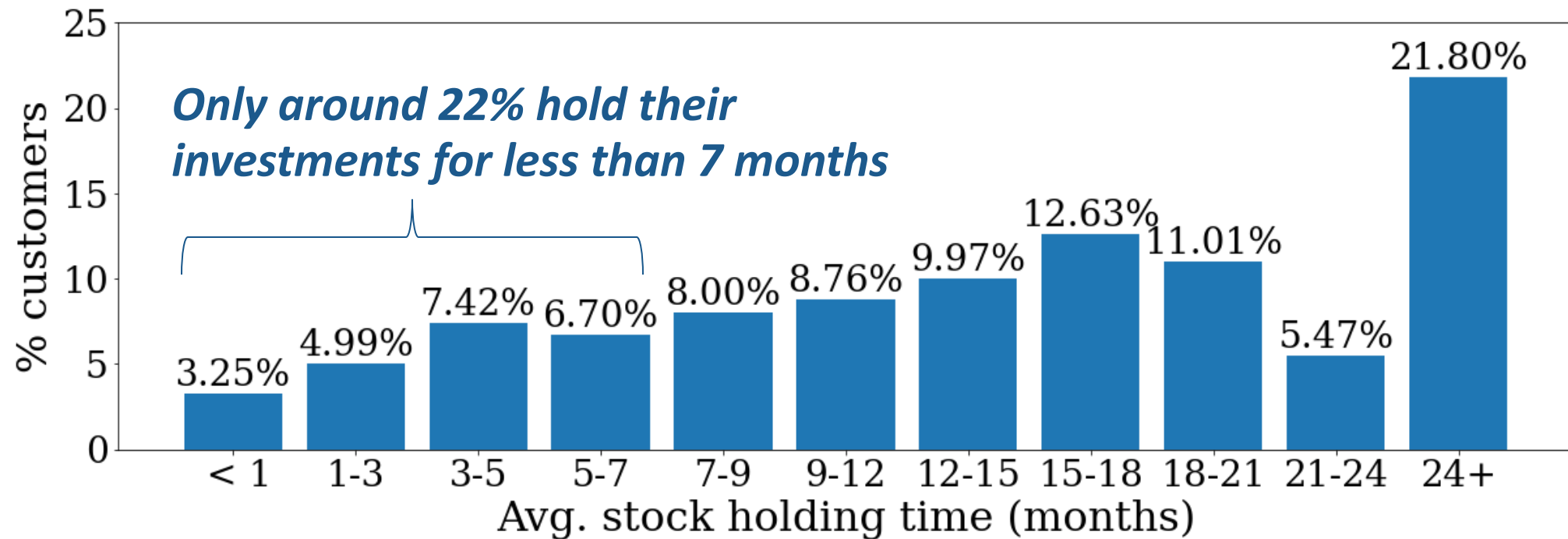
- Investments captured by nDCG might not necessarily align with a 6 month investment horizon.

Conclusions

- **We cannot use transaction-based metrics in exchange of profitability-based metrics – negatively correlated.**

- **Reasons**
  - Customer underperform the market average.
  - Global events impact on profitability patterns.
  - Customers might have different investment horizons / strategies.

- **Recommendations**
  - Consider changing market conditions when testing financial recommendation algorithms.
  - Customer strategies might confound our evaluation

Thanks for your attention

E-mail: Javier.sanz-cruzadopuig@glasgow.ac.uk
Twitter: @JavierSanzCruza
Webpage: https://javiersanzcruza.github.io

Link to the paper