



Human-Robot Interactions in Investment Decisions

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The Context

- **Individuals are more and more responsible of their pension savings' decisions**
 - Reduction in pay-as-you-go pension benefits
 - Gradual shift from DB to DC pension funds

- **Recent advances in technologies: possibilites to offer financial services in an innovative way**

- **Can robo-advisors help improve pension savings' decisions ?**



Complex investment decisions: Numerous biases

Low participation to the stock market

Higher for **wealthy households, more financially educated** (Calvet et al., 2009 ; Van Rooij et al., 2011)

Insufficient diversification

In average 2 stocks (Polkovnichenko, 2005), employer stock

Misunderstanding of diversification benefits (von Gaudecker, 2015)



Domestic or familiarity bias

(Coval and Moskowitz, 1999 ; Bekaert et al., 2015 ; Massa et Simonov, 2006 ; Bianchi and Tallon 2018)

Limited attention

Investors observe their portfolio infrequently, more in **rising markets** (“Ostrich effect”, Olafsson and Pagel, 2021)

In particular for investors with low financial literacy

(Guiso et al., 2003 ; Lusardi and Mitchell, 2014; Bianchi, 2018)

Can Technology Help?

— Robo-advisors

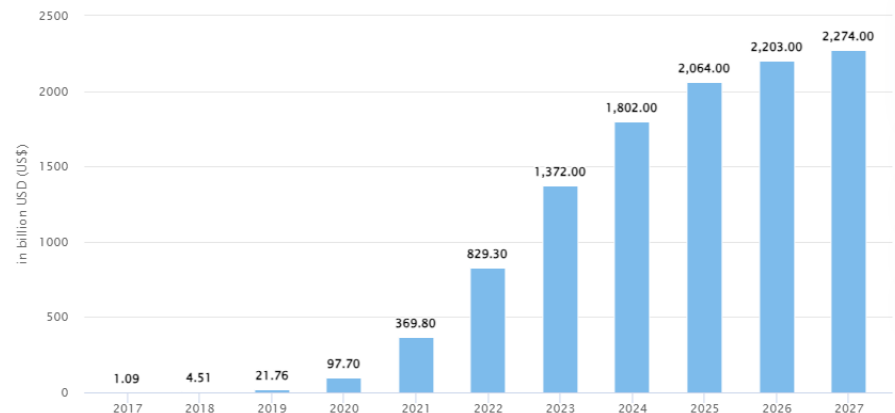
- Online platform providing **financial advice** or allowing **automated management** of a portfolio of assets
- Direct **digital relationship**

— How they work

- Define goals
- Assess personal preferences
- Construct and communicate optimal investment strategy
- Alerts are sent / portfolios rebalanced automatically

— Global robo-advice market is around **\$1.5 trn**

- AUMs worldwide are projected to reach \$2.3 trn in 2027 (Statista)



Notes: Data shown is using current exchange rates and reflects market impacts of the Russia-Ukraine war.

Most recent update: Aug 2023

Source: Statista Market Insights

Robo-advisors

— Types of robo-advisors (European Parliament, 2021)

Personalized Robo-advice

- Software provides investment advice based on clients preferences
- Client **makes investment decision**



Relies on **human-robot interaction**

Managed account

- Software manages financial instruments on behalf of the client, rebalancing the portfolio
- The robo-advisor **does not need client approval** for investment decisions

The Promises of Robo Advisors

- **Improved clients' knowledge and personalization**
 - Detailed **questionnaire**
 - Partnerships with **financial account aggregators**, platforms of investment, lending, and tax calculation

- **Reduced bias in clients' treatment**
 - But in practice, robots are mainly used by **young people**

- **Financial inclusion**
 - By reducing costs, new technologies can reach traditionally under-served
 - Robo-advisors require **lower initial capital** to open an account
 - They charge **lower fees** than human advisors

Human-Robot Interactions

- Are robots intended to **replace or promote investors' judgement** and actions ?
- **Humans-in-the-loop may be harmful to performance**
 - Ge et al. (2021) on peer-to-peer lending, Green and Chen (2019) on judges decisions
- **But human-robot interactions can reduce algo aversion**
 - Algo aversion can be partly overcome when letting people chose (Dietvorst et al., 2018 ; Burton et al. 2020)
- Long-term effects of robo advice: promote **learning and financial capabilities?**

 **Optimal degree of automation?**

This Paper

- **Robo-advisor introduced by AMUNDI on Employee Savings Plans**
 - Robo builds the investor's profile, suggests a portfolio allocation, and sends alerts over time in case of deviations from the target
- **Investors are the **ultimate decision makers** (as opposed to managed accounts)**
 - Focus on human-robo interaction: "intelligence augmentation" (IA) rather than AI, often about substitution
- **Sample includes investors with **small portfolios**, little experience and typically no access to financial advice**
 - Large debate on financial inclusion and financial inequalities
- **Exploit knowledge of the robo rules and different sources of variation**
 - Allows addressing self-selection issues

Main Results

- Significant **changes in investors' decisions** when robot provides investment and rebalancing recommendations while investors retain full control on their portfolio ?
 - Increased **attention** after take up (complementarity)
 - Increased **risk exposure** (+3%)
 - Increased **trading and rebalancing activities**
 - Increased **portfolio returns** (+2%)
- **Automatic rebalancing** would improve only marginally
 - Cost of letting people chose is small (2.5bp)
 - But significant heterogeneity across investors
 - Investors are less likely to follow the recommendation during bear markets

Data

— Employee Savings Plans

- Each year, employees receive a sum of money that they allocate between a menu of funds proposed by their employer
- Investment is locked in either for 5 years or until retirement
- Employees can increase their investment and rebalance their portfolio over time as they wish

— Our sample: all robo-takers (14,576 employees - out of 1.2M exposed) and a random sample of 20,000 robo-curious (+20,000 non-exposed, 20,000 exposed not-takers)

- Account level data (portfolio choices, returns, risk) + digital footprints (connections) + robo data (profile, proposed allocation)

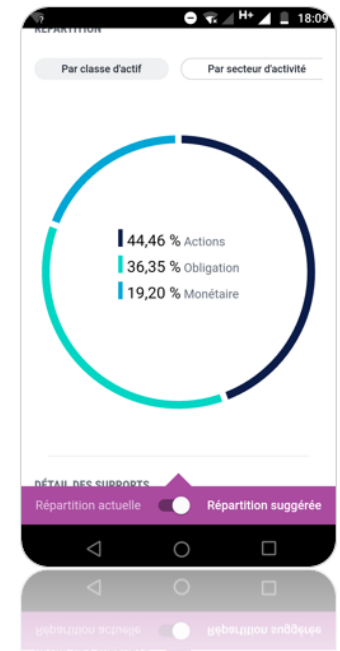
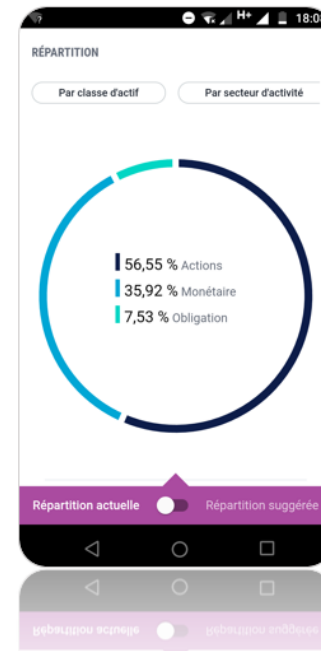
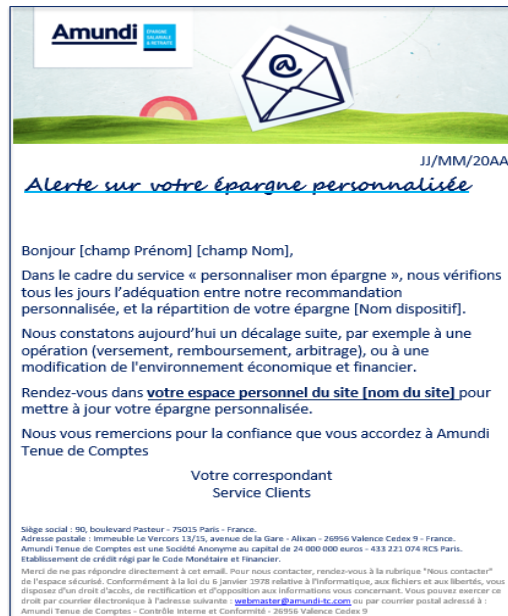
— Sample period Jan 2016/Jun 2021

- Robo introduction in Sept 2017
- Monthly frequency

Data

– Robo-treatment

- Elicits information (risk-aversion, financial knowledge, horizon)
- Proposes an allocation, and if accepted implements it
- Sends email alerts if current allocation is too far from proposed allocation



<p>PRUDENT</p> <p>Je veux avant tout limiter le risque pour mon épargne. J'ai bien compris, qu'en contrepartie, le potentiel de rendement serait limité.</p>	<p>MODÉRÉ</p> <p>Je suis prêt à prendre un risque modéré pour améliorer le potentiel de rendement de mon épargne.</p>	<p>EQUILIBRÉ</p> <p>Je recherche un juste équilibre entre potentiel de rendement et prise de risque en vue de cet objectif.</p>	<p>DYNAMIQUE</p> <p>Je recherche de la performance pour mon épargne, même si le risque est plus élevé.</p>	<p>AUDACIEUX</p> <p>Je vise avant tout la performance pour mon épargne. J'accepte pour cela les fluctuations importantes à la hausse comme à la baisse de mon épargne.</p>
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Basic Specification

– Difference-in-difference (OLS) regressions

- Control group are robo-curious (did the 1st profiling but didn't take the service)
- Standard errors are clustered at the individual/month level

$$y_{i,t} = \alpha_i + \beta T_{i,t} + X'_{i,t} \gamma + \mu_t + \varepsilon_{i,t}, \quad (1)$$

α_i and μ_t are individual and time fixed effects

$T_{i,t} = 1$ if individual i has taken the robo in period t

$X_{i,t}$ portfolio characteristics (past risky share, past returns, account value, ...)

Impact on Attention and Trading

- Robot is associated to an **increased level of attention and trading**
 - +0.28 connexions per month (avg=1) ; 0.09 additional trades per month (avg=0.05)
 - Investors do not take the robo as a **substitute for their own attention**
 - True even beyond the time of its subscription and the time of reception of the variable remuneration

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Variable	Number of Connections			Trades	Robo(>t)	Individual
Robo treated*after	0.283*** (0.0738)	0.270*** (0.0796)	0.138*** (0.0393)	0.0940*** (0.0139)	0.0443*** (0.00390)	0.00279 (0.00236)
Sample		No rem	No Sub			
Individual Fixed Effects		x	x			
Contract Fixed Effects				x	x	x
Time Fixed Effects		x	x	x	x	x
Observations	866,366	663,343	852,208	3,589,424	3,589,424	3,589,424
R-squared (within)	0.01	0.01	0.01	0.01	0.01	0.01

Col 2: we exclude month of variable rem ; Col 3: we exclude month of robo-subscription

Col 4: all trades ; Col 5: robo-trades ; Col 6: individual trades wo robot

The Role of Alerts

- Alerts associated with increased **attention** and **rebalancing** towards the target
 - More **connexions** (+0.31) and **rebalancing** (+0.29) per month (curious=0.14 and 0.10 resp.)
 - Reduction in the **distance to the target allocation**

	(1)	(2)	(3)	(4)	(5)
Dep. Variable	Connections	Rebalancer	Change in Distance	Actual - Target	Equity
Robo treated*Alert	0.308*** (0.0508)	0.295*** (0.0478)	-0.0391*** (0.00313)		
Alert	0.144 (0.117)	0.104*** (0.0153)	0.0331*** (0.00380)	-0.00613*** (0.00144)	
Alert MIF					0.00124* (0.000721)
Sample	Robo takers+curious			Robo takers	
Individual Fixed Effects	x				
Contract Fixed Effects		x	x	x	x
Time Fixed Effects	x	x	x	x	x
Observations	208,705	1,434,041	1,283,997	679,577	614,292
R-squared (within)	0.01	0.15	0.01	0.01	0.01

We compare the impact of robo-alerts with counterfactual alerts for curious

Col 4 & 5: restricted to robo takers, comparing robo-alerts with MIF alerts

Impact on (Dynamic) Risk Taking

- Robot is associated to an **increased asset allocation to risky assets**
 - + 2.9% in total equity share (avg 22%), +0.07 in beta (avg 0.4)
 - In particular when subsequent risky returns are larger

	(1)	(2)	(3)	(4)	(5)	(6)
	Equity		Beta			
Robo treated*after	0.0289*** (0.00344)	0.0729*** (0.0119)	0.0443*** (0.00970)	0.0370*** (0.00900)	0.0302*** (0.00872)	0.0199** (0.00865)
Mkt Ret. t+1*Robo treated*after			0.240*** (0.0380)			
Mkt Ret. t+1/t+3*Robo treated*after				0.274*** (0.0354)		
Mkt Ret. t+1/t+6*Robo treated*after					0.300*** (0.0530)	
Mkt Ret. t+1/t+12*Robo treated*after						0.263*** (0.0678)
Contract Fixed Effects	x	x	x	x	x	x
Time Fixed Effects	x	x	x	x	x	x
Observations	2,782,081	2,713,379	2,658,207	2,548,203	2,385,696	2,063,702
R-squared	0.01	0.01	0.01	0.01	0.01	0.01

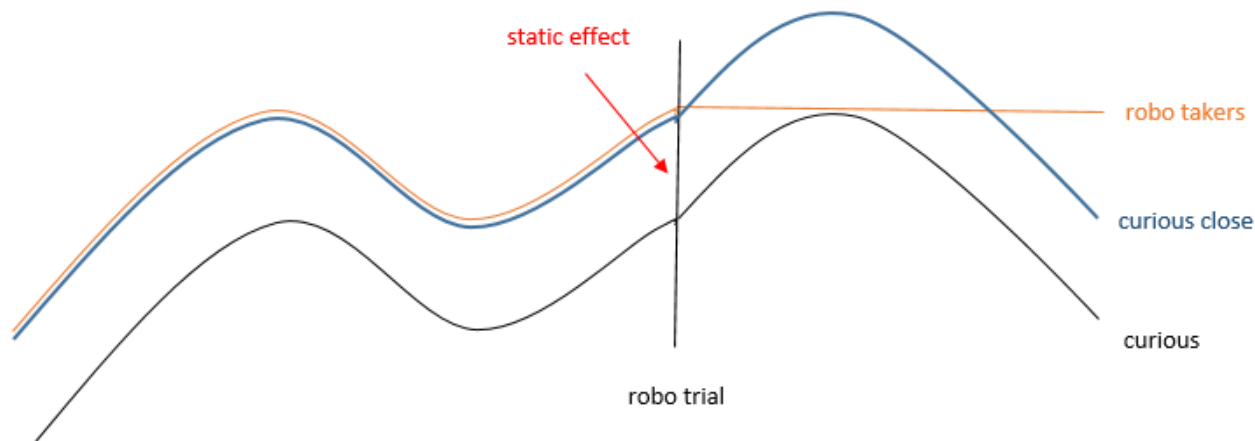
Impact on Performance

- Robot is associated with a **2% increase in realized returns**
 - Similar impact when considering expected returns from a 5-factor model
 - Back of the envelope calculation: over 17 years, final wealth would increase by 17KE for an avg investor with 34kE

	(1)	(2)	(3)	(4)
Dep. Variable	Realized Returns		Expected Returns	
Robo treated*after	0.0240*** (0.00468)	0.0209*** (0.00450)	0.0245*** (0.00311)	0.0201*** (0.00305)
Equity share		0.0932*** (0.00731)		0.135*** (0.00574)
Contract Fixed Effects	x	x	x	x
Time Fixed Effects	x	x	x	x
Observations	3,174,911	3,174,652	3,173,599	3,173,326
R-squared (within)	0.01	0.01	0.01	0.05

Static vs Dynamic Effects

- **“Curious close”** are a sub-sample of robo-curious with similar allocation than robo-takers when they experimented the robo
 - 1295 investors with difference in equity share <5%
 - They only differ from robo takers in the way they rebalance their portfolio over time
 - Static effect of the robot=0 ; dynamic effect measured from the return difference with robo-takers



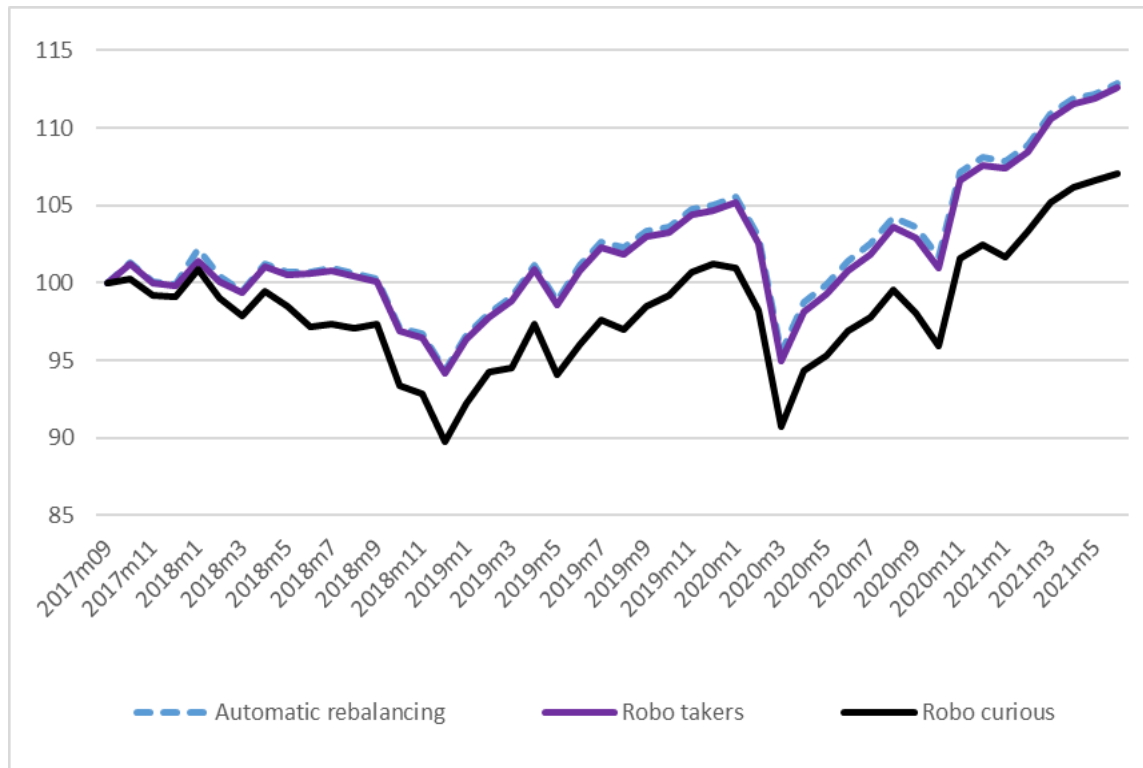
Impact on Performance (comparing to Curious Close)

- 1% of increase returns is due to dynamic effect (portfolio rebalancing)

Dep. Variable	(1)	(2)	(3)	(4)
	Realized Returns		Expected Returns	
Robo treated*after	0.00992*** (0.00334)	0.00939*** (0.00320)	0.0105*** (0.00226)	0.00971*** (0.00206)
Equity Share		0.0487*** (0.00464)		0.0718*** (0.00507)
Contract Fixed Effects	x	x	x	x
Time Fixed Effects	x	x	x	x
Observations	1,275,225	1,275,225	1,273,690	1,273,690
R-squared (within)	0.01	0.01	0.01	0.03

The Cost of Letting People Choose

- The cost of **letting people choose is minimal**
 - Counterfactual = automatic rebalancing at the time of alerts
 - Annual cost=2.5 bp compared to automatic rebalancing
 - Significant heterogeneity across investors



Source: Amundi ESR, authors' calculation

Who Rebalances on Alerts and When?

- Small impact of demographic characteristics, less rebalancing in bear markets
 - Male, older and richer investors more likely to rebalance

Dep. Variable	Rebalancer on Alert			Robo Rebalancer		
	(1)	(2)	(3)	(4)	(5)	(6)
Age	0.00173*** (0.000170)		0.00167*** (0.000181)	0.00269*** (0.000127)		0.00311*** (0.000138)
Female	-0.0150*** (0.00381)		-0.0193*** (0.00404)	0.0170*** (0.00286)		0.0208*** (0.00311)
Total account value (ln)	0.0133*** (0.00131)		0.00927*** (0.00135)	-0.0191*** (0.000961)		-0.0345*** (0.00102)
Variable remuneration (10k)	-0.0078 (0.00527)		0.0003 (0.00553)	-0.0681*** (0.00385)		-0.0378*** (0.00417)
Past equity share	-0.0463*** (0.00879)		-0.0535*** (0.00923)	-0.0507*** (0.00586)		-0.101*** (0.00634)
Past returns	0.00251 (0.106)		-0.367*** (0.108)	0.153** (0.0657)		-0.147** (0.0701)
Bear market		-0.257*** (0.00526)	-0.257*** (0.00527)		-0.000520 (0.00515)	0.00660 (0.00510)
Time FE	x			x		
Observations	70,358	70,541	70,358	62,453	62,879	62,453
R-squared (within)	0.01	0.03	0.04	0.03	0.01	0.04

Discussion

- Robo allows to induce **significant changes in investors' behavior**
 - Increased **attention, risk taking, trading activity**
 - Change in dynamic behaviors (**rebalancing** towards the target allocation)
 - **Increase risky exposure** when subsequent risky returns are larger
 - **Improved performance**

- The cost of **letting people choose** is minimal
 - Less rebalancing during bad times

- Role of **human-robot interactions**
 - Keeping humans ultimate decision makers **brings trust**
 - Human robot interactions can **improve financial capabilities**

- Open questions
 - **Long term effects? Effects in bad times?**

References

- Bianchi M. and M. Brière (2023), « Human-Robot Interactions in Investment Decisions », Forthcoming.
- Bianchi M. and M. Brière (2021), « Augmenting Investment Decisions with Robo-Advice », https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3751620
- Bianchi M. and M. Brière (2021), « Robo-Advising: Less AI and More XAI? », https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3825110

– DISCLAIMER

The data used to carry out this study come from the processing of record keeping and account keeping of AMUNDI ESR employee and pension savings accounts. These data have been analyzed anonymously for scientific, statistical or historical research purposes.

– MENTIONS LÉGALES

Amundi Asset Management

Société Anonyme au capital social de 1 086 262 605 euros

Société de Gestion de Portefeuille agréée par l'AMF sous le n° GP 04000036

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