Responses to risk-shifting nudges in portfolio allocation decisions

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1. Abstract

- Risk (portfolio) allocation choices often involve segregated risky and risk-free components:
  - e.g. investments with transaction costs, insurance, etc.
- Motivating question: **Can changing the relative segregation of risky and risk-free components of choices, nudge portfolio (resource) allocation decisions?**
- We present a theoretical basis for why and when such nudges might work
- This is tested experimentally and we detect changes in portfolio allocation decisions
- There is structural heterogeneity in these changes based on both individual differences and differences in the statistical nature of choice problems
- We present a novel hierarchical latent cognitive modeling approach:
  - This identifies how different factors affect different aspects of the cognitive processes underlying shifts in decision making, in response to risk framing manipulations.
  - Importantly, it captures latent parameters that underly our theoretical basis for how such nudges might work, as well as the link between individual and choice structure differences and heterogeneity in these latent parameters.

2. Introduction: A theoretical basis for nudges

Choice paradigm: Allocation of resources across multiple risky prospects

Illustrative example: Allocate resources (w) between 4 prospects (gambles)

Choice set – framing 1

i	p_S	v_S	p_F	v_F	C_i	EV	SD	w_i
1	0.5	5.2	0.5	4.8	0	5.0	0.2	?
2	0.6	7.5	0.4	3.8	0	6.0	1.8	?
3	0.7	9.5	0.3	1.1	0	7.0	3.8	?
4	0.8	10.9	0.2	-3.5	0	8.0	5.8	?

Choice set – framing 2

i	p_S	v_S	p_F	v_F	C_i	EV	SD	w_i
1	0.5	6.2	0.5	5.8	-1.0	5.0	0.2	?
2	0.6	9.5	0.4	5.8	-2.0	6.0	1.8	?
3	0.7	12.5	0.3	4.1	-3.0	7.0	3.8	?
4	0.8	14.9	0.2	0.5	-4.0	8.0	5.8	?

p_S = Probability of success
p_F = Probability of failure
v_S = Outcome (value) on success
v_F = Outcome (value) on failure
C_i = riskless acquisition cost of prospect

v_i = Expected value of prospect i
d_i = Standard deviation of prospect I

w_i = Decision weight
%Allocation of resources to each of the prospects **to create a portfolio**

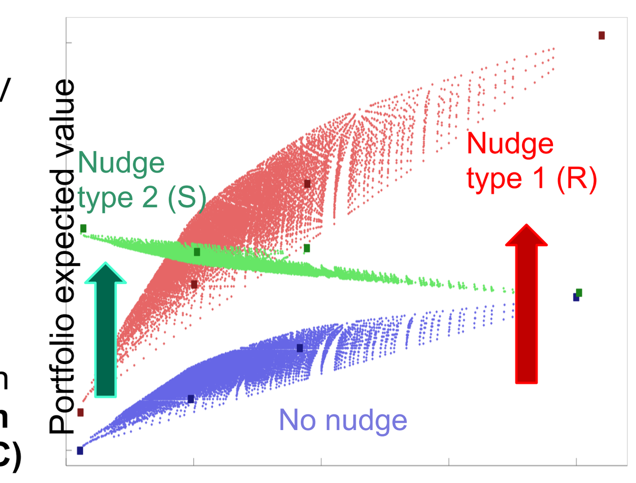
- The two choice sets are normatively equivalent: corresponding prospects (1-4) in each framing have the same expected value (EV), and standard deviation (SD)
- The choice sets differ in their surface structure – the split of outcomes between risky (v_S,v_F) and riskless components (C_i)
- IF the riskless component (C_i) receives higher or lower attentional focus (salience) compared to the risky components (non-linear or weighted linear additivity), this could ***distort the perceived decision space*** in the second framing, thus changing the perceived value and also the resulting investment proportions across the 4 prospects.

Can such portfolio allocation decisions be nudged?

- IF the **attentional salience to riskless components (C) is lower** than normative AND:
  - riskless components are **positively** correlated to the risk-reward levels of the prospects, THEN the decision space is distorted to make **riskier prospects more appealing: Nudge type 1 (R): C_i increases with (v_i, d_i)**
  - riskless components are **negatively** correlated to the risk-reward levels of the prospects, THEN the decision space is distorted to make **safer prospects more appealing: Nudge type 2 (S): C_i decreases with (v_i, d_i)**
- The distortion of the decision space is reversed if attentional salience to riskless components is higher than normative, i.e. the direction of the nudges is reversed.

Figure: Illustrative distortion of the portfolio decision space

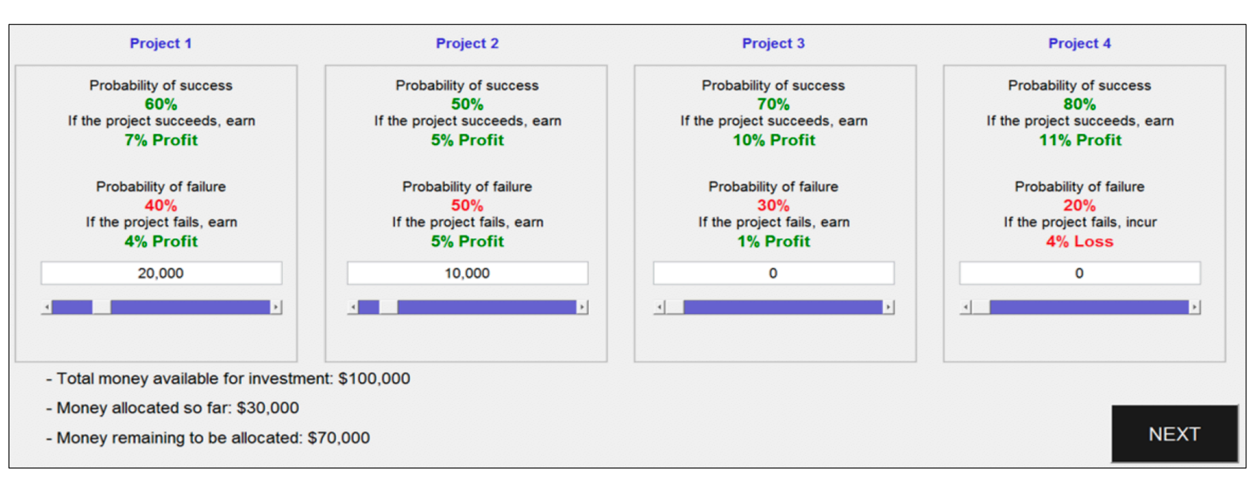
- Each point represents a combination of decision weights (w) and the resulting **portfolio** EV and SD
- **Blue:** Normative framing
- **Red:** Nudge Type 1 (R)
- **Green:** Nudge Type 2 (S)
- The red and green regions show how the normative (blue) decision space is distorted **if the attention salience to segregated costs (C) is lower than normative,**



3. Experiment Design

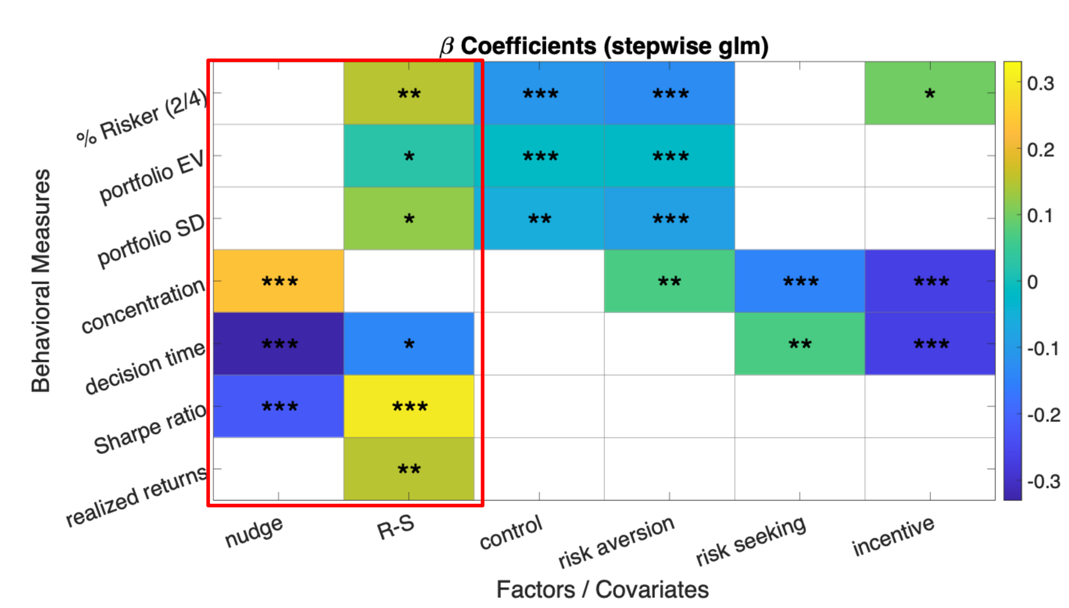
- **Task:** Allocate a fixed pool of capital between 4 prospects on each trial (trials are independent)
- **Blocked design:** No costs, Type 1 (costs, risk positively correlated), Type 2 (costs, risk negatively correlated)
  - Corresponding choice sets in each block matched on expected value and standard deviation
- **Factorial design with each block** (12 trial types in each block)
  - High (primarily gains) versus Low (mixed gains and losses) returns (2 levels)
  - Second order stochastic dominance (SOSD) vs no SOSD (2 levels)
  - Skew: None, positive, or negative skew (3 levels)
- **Allocation backstory and Feedback**
  - Backstory: Managerial investments in up to 4 projects, objective: to maximize overall returns
  - Feedback on success/failure and returns based on probabilistic outcomes after each trial
- **Behavioral measures**
  - Allocation to each prospect and calculation of EV, SD, concentration (Herfindahl index), and ex-ante Sharpe ratio (risk adjusted excess expected returns) of the resulting portfolio
  - Elicited risk-aversion, self-reported financial risk-seeking, locus of control scales

Illustrative experimental interface



4. Experimental Results

Figure: Stepwise GLM (Color-coded for standardized coefficient values)



nudge: Common effects for both type 1 and type 2 nudge

R-S: Differential effect of nudge type 1 (R) vs nudge type 2 (S)

%Risker (2/4) measure the allocation towards the 2 riskier prospects

* p<0.05; ** p<0.01; ***p<0.001

Effects, controlling for other factors

- Effect of **nudge conditions** was to increase the portfolio concentration (higher Herfindahl index) and lower the adjusted ex-ante Sharpe ratio (expected risk adjusted performance) of the selected portfolios.
- Effect of **Type 1** nudges (riskless cost positively correlated with higher risk) **vs Type 2** nudges (riskless cost negatively correlated with higher risks) was: higher ex-ante Sharpe ratios, higher standard deviation and expected value of portfolio, and higher proportion of riskier assets.
- Effect of **elicited risk aversion** was to lower the proportion allocated to riskier assets, as well as the portfolio EV and SD.
- Effect of **self-reported risk seeking** (financial DOSPERT) was to lower concentration of the portfolio
- Effect of financial incentives were to reduce concentration of the portfolio

5. Cognitive Modeling

Hierarchical latent cognitive model

- Each individual prospect evaluated based on cumulative prospect theory (CPT)
- Segregated prospects evaluated by separately processing saliency weighted (k) riskless acquisition costs under a CPT utility function before adding that to the risky components.
- Decision weights based on softmax rule with concentration parameters:

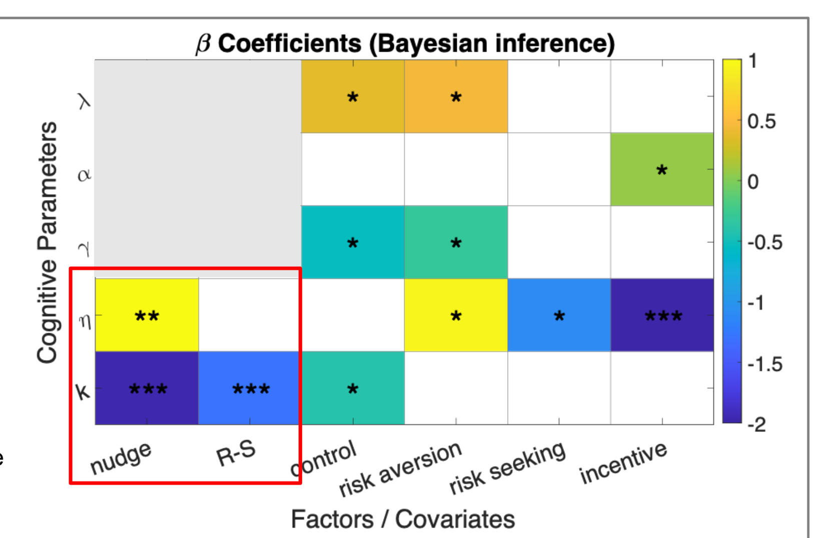
$$w_{ij} = \frac{1}{1 + \sum_k e^{-\eta\,(V_{ij} - V_{kj})}} \qquad i,k \in [1:N];\; k \neq i;\; j \in [1:J];$$

- Hierarchical model links CPT parameters to measured trait characteristics (locus of control, elicited risk aversion, self-reported risk-seeking) and whether or not real financial incentives were provided
- Hierarchical model links latent **attentional salience (k) and concentration parameters (η)** to above factors, but also allows them to vary based on the type of item (low vs high return, whether SOSD, and positive, negative, no skew), as well on the type of choice (risky vs riskless) and whether there was a risk-shifting nudge and the type of nudge (type 1 vs type 2)
- Implemented using Bayesian inference (MCMC)

Figure: Dependence of latent cognitive parameters on factors/covariates (color-coded for standardized coefficient values)

λ = CPT loss aversion parameter
α = CPT utility parameter (marginal sensitivity)
γ = CPT non-linear probability weighting
η = concentration parameter
k = attentional salience to riskless costs

nudge: Common effects for both type 1 and type 2 nudge
R-S: Differential effect of nudge type 1 (R) vs type 2 (S)
* Bayes Factor (BF): * BF>1; ** BF.3; *** BF>10



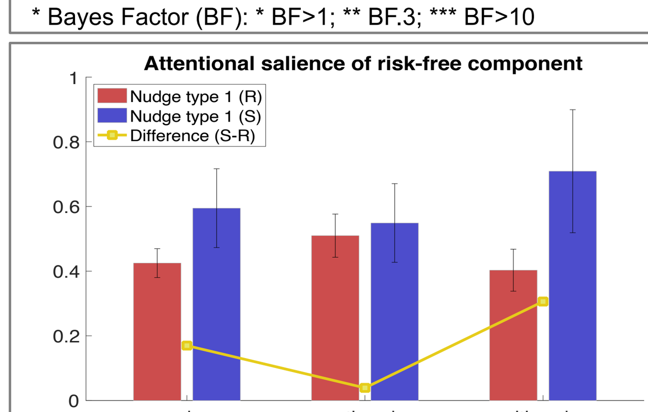


Figure: Differential effect of nudge type on attentional salience (hedonic / motivated reasoning) interacts with skewness

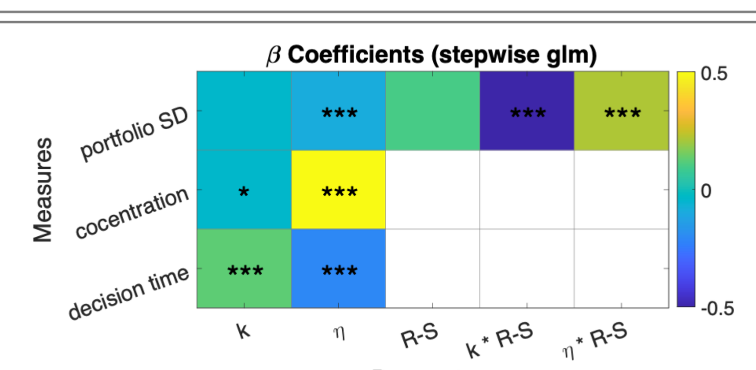


Figure: Beta coefficients from stepwise GLM. Measures the influence of k, η, and interactions with nudge type on behavioral measures

* p<0.05; ** p<0.01; ***p<0.001

Changes on account of nudged choice frames can be accounted for by:

- ***Complexity driven concentration***: Increased concentration parameter under nudge frame beyond the degree of concentration that would arise simply from a distortion of the decision space. A probable cause of such concentration could be the increased complexity of the choice structure.
- ***Reduced attentional salience to riskless components***: This distorts the decision space, by making riskier choices more appealing in nudge type 1, and safer choice more appealing in nudge type 2. This component is not dependent on the type of nudge.
- ***Hedonic reduction in salience / Motivated reasoning***: Nudge type 1, where lower salience to riskless components distorts the decision space in favor of riskier (high risk-high reward) prospects shows a larger reduction in attentional salience than nudge type 2. We attribute this to some form of hedonic reduction or motivated reasoning, where the implicit bias to invest in prospects with higher prospective rewards drives lower salience on riskless cost components.
- ***Reduction of salience interacts with skewness:*** The hedonic or motivated reduction in salience theory seems likely since we see a larger effect of such reduction (difference between the nudge types) when the prospects have a positive skew (higher probabilities for successful outcomes, while controlling for expected value) compared to no skew, and the difference between nudge types almost disappears when prospects have negative skew (higher probabilities for failure outcomes, while controlling for expected value)
- ***Interaction of salience (k) with nudge type:*** shows a strong influence on portfolio SD, with lower attentional salience under nudge type 1 increasing SD, but lower attentional salience under nudge type 2 reducing SD. This ties in with our theoretical basis of the perceived distortion of risk under the two types of nudges.

6. Conclusions

- **Systematic correlation of riskless transaction costs with the risk-reward structure** of individual prospects **can create risk-shifting nudges**, with the potential of pushing choices towards both riskier or safer portfolios, depending on the direction of the correlation (manipulated or naturally occurring) but also the attentional salience (dependent on individual traits and choice specific contextual factors).
- Hierarchical cognitive model allows **measuring the critical latent factor of attentional salience** as well as concentration, and measure how they vary with context.
- **Multiple mechanisms** may be associated with risk-shifting nudges, including response to increased choice complexity, implicit attentional bias towards uncertain components, and explicit biases based on hedonic or motivated reasoning.

7. Key references

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