Reconciling health and wealth background risks: an analysis of risky behavior when higher-order preferences are considered

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Pre-existing risks:

- There is no market for trading directly on this risk (Schlesinger and Stapleton 2018)
- Usually considered as exogenous and not subject to transformations by the decision maker (Guo et al. 2016)

Examples: health status, income instability, environmental disasters

Individuals face bundles of these risks

Focus on health (background) and financial risks (foreground)
Background risks – why are they important in the case of health?

- Health shocks and the expectation of future health shocks represent a risk in terms of:
  - Large out of pocket expenses (Edwards 2008)
  - Labour income risk (Heaton and Lucas 2000)
  - Financial planning horizons (through life expectancy, Love and Perozek 2007)
  - Saving decisions (Baptista 2008)
Background risks – why are they important for risky decisions?

- Adding background risk usually reduces welfare (Pratt and Zeckhauser 1987, Kimball 1993, Gollier and Pratt 1996)

- However, individuals with “diminished psychological sensitivity” have the opposite behavior (Quiggin and Chambers 1998)
Risk aversion is only one piece of an individual’s risk profile:

- We focus on measuring prudence (third-order) and temperance (fourth-order, Ebert and Wiesen 2011)

Other higher-order preferences could also be measured (edginess, 6th order and so on..., Deck and Schlesinger 2014)
Questions

1. Do risky decisions differ depending on the health status of the individual?

2. Does the introduction of an additional exogenous financial background risk make individuals more or less risky?

3. Are higher-order risk preferences a determinant of risky decisions when additional background risk is added?
Experimental Design
Experimental design

- Two main tasks + one treatment (exogenous background risk lottery)

**Task 1**
- Individuals choices on a series of 16 risky decisions to measure risk and higher-order risk preferences

**Task 2**
- Questionnaire to elicit individual background risks
- Additional socioeconomic survey
Task 1
Experimental design: task 1

- Elicits individual degrees of riskiness, prudence and temperance
- Use the experimental risk apportionment approach from Eeckhoudt and Schlesinger (2006)
  - Defines risk aversion, prudence and temperance over 50-50 lottery pairs
- We follow the choice task values from Deck and Schlesinger (2008)
  - For prudence and temperance tasks
  - Construct comparable risk tasks
Experimental design: task 1

- Two choice sets of 16 tasks
  - One set pre-treatment
  - One set post-treatment
- Order of the tasks in each set is randomized
- Payments are determined to make different comparisons in terms of expected value, lottery values and initial sure amounts
Example task

You will receive E$10 +

[10 / -10] if the coin lands on *Heads* or *Tails* and

[5 / -5] if the coin lands on *Same* or *Different* outcome.
Example task

You will receive E$10 + [10 / -10] if the coin lands on Heads or Tails and [5 / -5] if the coin lands on Same or Different outcome.
You will receive E$10 + 
[10 / -10] if the coin lands on Heads or Tails and 
[5 / -5] if the coin lands on Same or Different outcome.
You will receive E$10 + [10 / -10] if the coin lands on *Heads* or *Tails* and [5 / -5] if the coin lands on *Same* or *Different* outcome.
You will receive E$10 +
[10 / -10] if the coin lands on *Heads* or *Tails* and
[5 / -5] if the coin lands on *Same* or *Different* outcome.
Task 2
Experimental design: task 2

- Individual background risk elicitation
- Main categories suggested by Cardak and Wilkins (2009), Noussair et al. (2014):
  - Health risk, labour income risk, committed expenditure risk, liquidity and credit constraints, investment substitutes, mandatory retirement savings, preferences
  - We focus on health risks
- Short socioeconomic survey at the end of study
Experimental design: treatments

- Additional background risk lotteries ("extra” financial risk)
- Added between choice task sets (task 1)
- Four treatments which depend on the lottery type:
  - **No BR**: no additional lottery
  - **Upside BR**: 50% chance of winning E$50 and 50% chance of losing E$0
  - **Mean-zero BR**: 50% chance of winning E$50 and a 50% chance of losing E$50
  - **Downside BR**: 50% chance of winning E$0 and 50% chance of losing E$50
- Outcome of the lottery determined by a die roll at the end of the experiment
Your outcome

50% chance of winning E$0

50% chance of losing E$50

ODD = (1, 3, 5)  E$0

EVEN = (2, 4, 6)  - E$50
<table>
<thead>
<tr>
<th>Treatment</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
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<td>Risk + higher order</td>
<td>No BR</td>
<td>Risk + higher order</td>
<td>Risk + higher order</td>
<td>Post-experimental survey</td>
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<td>elicitation</td>
<td>attitudes elicitation</td>
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<td>Mean-zero BR</td>
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<td></td>
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<td>Upside BR</td>
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<tr>
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<td>Downside BR</td>
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<tr>
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<td>Risk + higher order</td>
<td>Individual background risk</td>
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<td>T8</td>
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<td></td>
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<td>Post-experimental survey</td>
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</table>
Experimental design: implementation

- Online experiment – Amazon Mechanical Turk
- Run in April-May 2018
- HIT payment of $0.5
- Individuals start with an endowment of 100 experimental dollars (E$), to avoid negative earnings
- Exchange rate: E$80:$1
- Instructions are recorded as a video
- Comprehension questions before tasks and after adding background risk
Experimental design: implementation

- Average payment: $1.56 ($0.54 s.d., max $3.19)
- Payment is composed of:
  - Sure amount
  - One, two, both or no lotteries
“Sick” = individual reports at least one chronic illness
“Healthy” = individual does not report any chronic illnesses

<table>
<thead>
<tr>
<th>BR Type</th>
<th>Sick</th>
<th>Healthy</th>
<th>Total</th>
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<tbody>
<tr>
<td>No BR</td>
<td>175</td>
<td>98</td>
<td>273</td>
</tr>
<tr>
<td>Mean-zero BR</td>
<td>175</td>
<td>99</td>
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<tr>
<td>Upside BR</td>
<td>170</td>
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<td>158</td>
<td>116</td>
<td>274</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>678</strong></td>
<td><strong>423</strong></td>
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Sick versus healthy- avg. number of RA choices (0 to 6)

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<tr>
<td>Healthy</td>
<td>2.77</td>
<td>2.58</td>
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</table>

Significance: ***
Sick versus healthy- avg. number of RA choices (0 to 6)

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<tr>
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<th>Post-treatment</th>
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</thead>
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<tr>
<td><strong>Sick</strong></td>
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<td>3.02</td>
</tr>
<tr>
<td><strong>Healthy</strong></td>
<td>2.77</td>
<td>2.58</td>
</tr>
</tbody>
</table>
By treatment
Results – sick versus healthy: Downside BR

- Expectations:
  - Sick individuals make less risky decisions and choose safer portfolio allocations when faced with potential losses, uncertainty of future income (Rosen and Wu 2004, Heaton and Lucas 2000, Guiso et al. 1996))
2.96

3.20

2.70

2.67

Number of Risk Averse Choices

Pre-treatment Sick

Post-treatment Sick

Pre-treatment Healthy

Post-treatment Healthy

***
Results – sick versus healthy: Downside BR

**K-S Test p=0.04**

Who moves
Results – sick versus healthy : Upside BR

- Expectations:
  - No experimental evidence for the case of gains only?
The graph illustrates the number of risk-averse choices made by participants in the pre-treatment and post-treatment phases, categorized by health status.

- **Pre-treatment (Sick):** 2.82
- **Post-treatment (Sick):** 3.03
- **Pre-treatment (Healthy):** 3.11
- **Post-treatment (Healthy):** 2.79

An asterisk (*) indicates a statistically significant difference between the post-treatment and pre-treatment phases.
Results – sick versus healthy : Upside BR

- Expectations:
  - No experimental evidence for the case of gains only?

- Results:
  - No significant changes for sick subjects
  - Healthy subjects become riskier

- Possible reasons:
  - Playing with house money when potential gains are included (Deck and Schlesinger 2010, Thaler and Johnson 1990)
Expectations:
- Lusk and Coble (2008) find a reduction in the level of individual riskiness

Results:
- No significant changes in the number of risk averse choices for sick or healthy individuals

Possible reasons:
- Stakes are small compared to decisions outside the laboratory (Maier and Rüger 2012)
- Higher stakes outside the laboratory could lead to more speculative behavior, particularly to cover for potential losses, where subjects’ might aggregate different risks to have one positive outcome
Between-subject analysis
Results – between subject analysis

- Impact of treatments on the number of risk averse choices
- Ordered logit models
- Dependent variable is number of choices: 0 to 6
- Include health status, gender, prudent and temperate choices, income and interactions
<table>
<thead>
<tr>
<th>D.V.: Number of risk averse choices (post-treatment)</th>
<th>No BR</th>
<th>Mean-zero BR</th>
<th>Upside BR</th>
<th>Downside BR</th>
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<td>(0.091)</td>
<td>(0.095)</td>
<td>(0.093)</td>
<td>(0.096)</td>
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<td>-0.025</td>
<td>0.113</td>
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<td>(0.287)</td>
<td>(0.280)</td>
<td>(0.284)</td>
<td>(0.289)</td>
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<td><strong>Sick</strong></td>
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<tr>
<td>-0.578</td>
<td>1.510+</td>
<td>1.107</td>
<td>1.478+</td>
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<td>(0.844)</td>
<td>(0.790)</td>
<td>(0.790)</td>
<td>(0.816)</td>
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<td><strong>Female</strong></td>
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<td>-0.378</td>
<td>-0.297</td>
<td>0.066</td>
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<td>(0.430)</td>
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<td><strong>Number of prudent choices</strong></td>
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<td>0.326+</td>
<td>0.102</td>
<td>0.312+</td>
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<td>(0.213)</td>
<td>(0.188)</td>
<td>(0.172)</td>
<td>(0.160)</td>
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<td><strong>Number of temperate choices</strong></td>
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<td>-0.321</td>
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<tr>
<td>(0.269)</td>
<td>(0.231)</td>
<td>(0.244)</td>
<td>(0.221)</td>
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<tr>
<td>0.119</td>
<td>-0.636*</td>
<td>-0.376+</td>
<td>-0.471+</td>
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<tr>
<td>(0.239)</td>
<td>(0.276)</td>
<td>(0.226)</td>
<td>(0.274)</td>
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<tr>
<td><strong>Sick * Number of temperate choices</strong></td>
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<td>0.319</td>
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<td>-0.266</td>
<td>0.382</td>
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<tr>
<td>(0.318)</td>
<td>(0.341)</td>
<td>(0.348)</td>
<td>(0.326)</td>
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<td>0.092</td>
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<td>(0.223)</td>
<td>(0.222)</td>
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<td><strong>Temperance * Sick * Female</strong></td>
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<tr>
<td>(0.248)</td>
<td>(0.318)</td>
<td>(0.307)</td>
<td>(0.299)</td>
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<td><strong>Prudence * Temperance * Sick</strong></td>
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<tr>
<td>0.684</td>
<td>0.663</td>
<td>0.550</td>
<td>1.444*</td>
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<tr>
<td>(0.660)</td>
<td>(0.689)</td>
<td>(0.677)</td>
<td>(0.697)</td>
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<tr>
<td><strong>Low Income</strong></td>
<td></td>
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<tr>
<td>0.240</td>
<td>0.512</td>
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<tr>
<td>(0.750)</td>
<td>(0.684)</td>
<td>(0.720)</td>
<td>(0.753)</td>
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<tr>
<td>(0.254)</td>
<td>(0.257)</td>
<td>(0.250)</td>
<td>(0.263)</td>
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</tr>
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</table>

| N       | 175   | 170   | 167   | 171   |
Results – between subject analysis

- Sick subjects make an average of 1.5 more risk averse choices after being treated
  - Strategy to counteract exogenous potential losses
- Smaller effect for number of prudent choices in the same direction
- Sick and prudent individuals make less risky choices compared to healthy and imprudent
  - Diminished sensitivity to risk (Quiggin 2003)
Results – between subject analysis

- Effect of temperance when exogenous potential losses are introduced
  - Indirect effect: only significant for subjects who are sick, prudent and temperate
    (Kimball 1993, Elmendorf and Kimball 2000)
- Low income, prudent subjects are less risky when facing potential gains
  - Potential for precautionary savings (Cardak and Wilkins 2009, Edwards 2008)
Conclusion

- Economic decisions take place in the context of multiple and correlated risks
- Health and financial (risky) decisions are related: sick individuals are less financially risky than their healthy counterparts (Bressan et al. 2014, Cardak and Wilkins 2009)
- Evidence towards cross-risk vulnerability (Malevergne and Rey 2009)
- The relationship between health and financial risks is not linear
Current work

- Are subjects reference dependent? (Kőszegi and Rabin 2006)
- Mental, physical and comorbidities
- Changes in higher-order risk preferences >2
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Higher-order risk preferences

- Prudence is
  - The (positive) third derivative of the utility function under EUT (Kimball 1990)
  - Equivalent to an aversion to increases in downside risk (Menezes et al. 1980)

- Temperance is
  - The (negative) fourth derivative of the utility function (Kimball 1993, Menezes and Wang 2005)
  - A dislike for negative kurtosis

- Higher-order preferences have also been defined in a non-parametric way
  (Eeckdhoudt and Schlesinger 2006):
Building your risk profile
Building your risk profile: risk aversion

You will receive E$10 +
[1 / 1] if the coin lands on Heads or Tails and
[5 / 5] if the coin lands on Same or Different outcome.
Building your risk profile: prudence

You will receive E$12.50 + [5 / -5] if the coin lands on Heads or Tails and [1 / 1] if the coin lands on Same or Different outcome.

Prudent

B3

W+k

W+ε

W+k+ε

A3
Building your risk profile: temperance

You will receive E$55 + [5 / -5] if the coin lands on Heads or Tails and [45 / -45] if the coin lands on Same or Different outcome.

Temperate

\[
W + \varepsilon_2
\]

W + \varepsilon_1

B4

W

A4

W + \varepsilon_1 + \varepsilon_2
<table>
<thead>
<tr>
<th>Decision</th>
<th>Preference type</th>
<th>Sure amount (W, E$)</th>
<th>First item (k, E$)</th>
<th>Second item (δ, E$)</th>
<th>Expected Payoff</th>
<th>Order of tasks Stage 1</th>
<th>Order of tasks Stage 2</th>
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<td>10</td>
<td>[1/1]</td>
<td>[1/1]</td>
<td>11</td>
<td>3</td>
<td>15</td>
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<td>9</td>
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<td>[9/9]</td>
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<td>[9/9]</td>
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<tr>
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<td>[5/-5]</td>
<td>[1/1]</td>
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<tr>
<td>10</td>
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<td>10.5</td>
<td>[9/9]</td>
<td>[1/-1]</td>
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<tr>
<td>11</td>
<td>Prudence</td>
<td>12.5</td>
<td>[5/5]</td>
<td>[5/-5]</td>
<td>15</td>
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<td>6</td>
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<tr>
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Downside BR: How are individuals changing?

![Bar chart showing percentage changes in riskiness before and after treatment for sick and healthy individuals.](chart.png)

- **Pre-treatment** vs. **Post-treatment**
  - **Sick**
    - Low Riskiness
    - Mid Riskiness
    - High Riskiness
  - **Healthy**
    - Low Riskiness
    - Mid Riskiness
    - High Riskiness

Legend:
- Low Riskiness
- Mid Riskiness
- High Riskiness

*** indicates significant difference.