Measurement Error in Subjective Expectations and the Empirical Content of Economic Models

Tilman Drerup    Benjamin Enke    Hans-Martin von Gaudecker
Universität Bonn

Econometric Conference in Honour of François Laisney
Strasbourg, 4 June 2015
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Imprecise Measures of Subjective Expectations and the Explanatory Power of Economic Models

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Motivation

- “Stock market participation puzzle”
Motivation

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- Pessimistic stock market expectations as an explanation?
Motivation

▶ “Stock market participation puzzle”

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Fairly low explanatory power of subjective beliefs
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  Measurement challenging for some respondents
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<thead>
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Motivation

- “Stock market participation puzzle”
- Pessimistic stock market expectations as an explanation?

Fairly low explanatory power of subjective beliefs

Measurement challenging for some respondents

Heterogeneous decision processes?

- Use impreciseness in measures of beliefs to proxy the “propensity to use economic reasoning”
What we do

- Construct two (linear) indices in Internet Panel data:

  1. Economic model (µ of stock market return expectations)
  2. Individual-level impreciseness in measures of return expectations (discrepancy between repeated measures, confidence in estimates, experienced difficulty in completing the tasks)

- Estimate stock market participation using double-index binary choice model due to Klein and Vella (2009)

- Preview of results for simplified model
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- Estimate stock market participation using double-index binary choice model due to Klein and Vella (2009)
- Preview of results for simplified model
Predicted probability to hold risky assets, model with mean beliefs and measurement error proxies only
Outline

Motivation

Model and Empirical Strategy

Data and Experiment

Results

Discussion and conclusions
Risky asset participation with transaction cost

\[ Y \equiv \mathbb{I}\{\theta > 0\} = \begin{cases} 
1 & \text{if } \theta^{\text{opt}} \left( \mu_{t+1} - \mu_{t+1}^{\text{safe}}, \sigma_{t+1}^{\text{risky}}, \gamma \right) - f(X^{\text{ta}}) > \varepsilon \\
0 & \text{otherwise.} 
\end{cases} \]

- Approximate \( \theta^{\text{opt}}, f(X^{\text{ta}}) \) by linear functions
Risky asset participation with transaction cost

\[ Y \equiv \mathbb{I}\{\theta > 0\} = \begin{cases} 1 & \text{if } \theta^{opt} \left( \mu_{t+1}^{\text{risky}} - \mu_{t+1}^{\text{safe}}, \sigma_{t+1}^{\text{risky}}, \gamma \right) - f(X^{ta}) > \varepsilon \\ 0 & \text{otherwise.} \end{cases} \]

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Risky asset participation with transaction cost

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- Issues with standard estimations:
  - Economics: Small(er than expected) effects of $\mu_{t+1}^{\text{risky}} - \mu_{t+1}^{\text{safe}}, \sigma_{t+1}^{\text{risky}}, \gamma$
  - Econometrics: Require homoskedasticity of $\varepsilon$, violated under our hypothesised mechanism
The relation of imprecise measures of beliefs and the economic model’s explanatory content

▶ Model:

Effortful reasoning about future states of the world
+ personal risk tolerance
The relation of imprecise measures of beliefs and the economic model’s explanatory content

- Model:

  Effortful reasoning about future states of the world
  + personal risk tolerance
  \[ \theta = 100 - \text{age} \]
  \[ \rightarrow \text{choice rule} \]
The relation of imprecise measures of beliefs and the economic model’s explanatory content

- Model:
  
  Effortful reasoning about future states of the world
  + personal risk tolerance
  → choice rule

- Alternative choice rules:
  - Follow others’ advice
The relation of imprecise measures of beliefs and the economic model’s explanatory content

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The relation of imprecise measures of beliefs and the economic model’s explanatory content

- Two sets of consequences:
  1. Different methods to elicit beliefs → divergent reports, low self-expressed confidence in estimates, tasks experienced as difficult and obscure
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2. Marginal effects of changes in beliefs on portfolio choice behavior small
The relation of imprecise measures of beliefs and the economic model’s explanatory content

Two sets of consequences:

1. Different methods to elicit beliefs $\rightarrow$ divergent reports, low self-expressed confidence in estimates, tasks experienced as difficult and obscure

2. Marginal effects of changes in beliefs on portfolio choice behavior small

$\Rightarrow$ Imprecise measures of beliefs informative about economic quantities of interest
Related evidence

- Many belief elicitation protocols lead to violation of the basic laws of probability
Related evidence

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- 50-50 responses seem to reflect epistemic uncertainty rather than a true belief
Related evidence

▶ Many belief elicitation protocols lead to violation of the basic laws of probability

▶ 50-50 responses seem to reflect epistemic uncertainty rather than a true belief

▶ Imprecise measures of risk preferences related to socio-economics
Econometric strategy

- Consequences of previous arguments:

\[ \varepsilon \text{ will increase in measurement error} \]

Group-specific means may be \( \neq 0 \) (e.g., advice)

⇒ Double-index model (Klein and Vella, 2009) based on:

\[
P(Y = 1 \mid X_{\text{mod}} \beta_{\text{mod}}, X_{\text{me}} \beta_{\text{me}}) = \ h(X_{\text{mod}} \beta_{\text{mod}}, X_{\text{me}} \beta_{\text{me}})
\]

- Measurement index further parameterizes \( \varepsilon \) (random component is systematic to some extent)

- \( h(\cdot, \cdot) \) is nonparametric link mapping the indices for the economic model and measurement error onto stock market participation probabilities
Econometric strategy

- Consequences of previous arguments:
  - \( \text{Var}[\varepsilon] \) will increase in measurement error
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$\implies$ Double-index model (Klein and Vella, 2009) based on:

$$P(Y = 1 \mid X^{\text{mod}}\beta^{\text{mod}}, X^{\text{me}}\beta^{\text{me}}) = h(X^{\text{mod}}\beta^{\text{mod}}, X^{\text{me}}\beta^{\text{me}})$$

- Measurement index further parameterizes $\varepsilon$ (random component is systematic to some extent)

- $h(\cdot, \cdot)$ is nonparametric link mapping the indices for the economic model and measurement error onto stock market participation probabilities
The estimator

\[ P(Y = 1 \mid X^{\text{mod}} \beta^{\text{mod}}, X^{\text{me}} \beta^{\text{me}}) = \frac{f_{Y=1}(X^{\text{mod}} \beta^{\text{mod}}, X^{\text{me}} \beta^{\text{me}}) \cdot P(Y = 1)}{f(X^{\text{mod}} \beta^{\text{mod}}, X^{\text{me}} \beta^{\text{me}})} \]
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- Identification up to location and scale requires 1 dedicated variable each
The estimator

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- Identification up to location and scale requires 1 dedicated variable each
- \( h(\cdot, \cdot) \) has to be sufficiently smooth
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- Identification up to location and scale requires 1 dedicated variable each
- \( h(\cdot, \cdot) \) has to be sufficiently smooth
- Compact support of all \( X \) \( \rightarrow \) multi-stage local smoothing
Outline

Motivation

Model and Empirical Strategy

Data and Experiment

Results

Discussion and conclusions
The LISS panel

- Internet-administered survey of \( \approx 5000 \) Dutch households
- Large and representative sample
- Rich demographics
- Select financial deciders in households with at least \( \mathbf{\text{€1,000}} \) in liquid wealth, initial sample \( \approx 2000 \)
Timeline of data collection

Aug 2013

Beliefs
(graphical, incentivised)

Portfolio
(real-world)

Sep 2013

Risk pref's
Beliefs
(one-shot)

Investment
(100 $)

Mar 2014

Update:
Beliefs,
Investment

Oct 2014

Debriefing,
Fin. Literacy
Payments
Timeline of data collection

Aug 2013
- Beliefs (graphical, incentivised)
- Portfolio (real-world)

Sep 2013
- Risk pref’s
- Beliefs (one-shot)
- Investment (100 €)

Mar 2014
- Update: Beliefs, Investment

Oct 2014
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Investment
(100 €)

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Incentivised Beliefs: Visual Task

- Based on Delavande and Rohwedder (2008)
- Incentives according to Hossain and Okui (2013) scoring rule, 1 in 10 respondents is paid
Expected AEX returns: Means

Subjective beliefs for AEX return: $\mu_{t+1}$
Expected AEX returns: Standard deviations

Subjective beliefs for AEX standard deviation: $\sigma_{t+1}$
Model ingredients

- Mean expected excess return of AEX over savings account
Model ingredients

- Mean expected excess return of AEX over savings account
- Standard deviation of AEX return expectations
Model ingredients

- Mean expected excess return of AEX over savings account
- Standard deviation of AEX return expectations
- Risk aversion. Index based on:
  - Staircase lotteries
  - Willingness to take risks in general
  - Willingness to take risks in the financial domain
Measurement error proxies

Quantitative:

- Absolute difference between mean belief from ball allocation task and from point estimate (AEX)
Measurement error proxies

Quantitative:

- Absolute difference between mean belief from ball allocation task and from point estimate (AEX)

Qualitative:

- Confidence in AEX return estimate
- Confidence return estimate of savings account
Measurement error proxies

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- Absolute difference between mean belief from ball allocation task and from point estimate (AEX)

Qualitative:

- Confidence in AEX return estimate
- Confidence return estimate of savings account
- Tasks (Aug, Sept) obscure? (Exit question)
Measurement error proxies

Quantitative:
  ▶ Absolute difference between mean belief from ball allocation task and from point estimate (AEX)

Qualitative:
  ▶ Confidence in AEX return estimate
  ▶ Confidence return estimate of savings account
  ▶ Tasks (Aug, Sept) obscure? (Exit question)
  ▶ Tasks (Aug, Sept) difficult? (Exit question)
Beliefs: One-shot questions

- Type in point estimate of 1-year ahead return of:
  - AEX
  - Philips shares
  - Standard savings account

- Indicate confidence in each estimate with a slider
One-shot estimates for return of AEX

Subjective beliefs (direct question): Expected return
Joint density of average belief measures ($\rho = 0.17$)
Absolute differences between average belief measures
Transaction cost proxies

(may affect both measurement error and model)

- Household financial wealth
- Net household income
- Education
- Age
<table>
<thead>
<tr>
<th></th>
<th>Statistic</th>
<th>Index</th>
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<tbody>
<tr>
<td>Holds risky assets</td>
<td>0.25</td>
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<td>Subjective beliefs: $\mu_{t+1}^{AEX} - \mu_{t+1}^{sav.\ acc.}$</td>
<td>-1.18</td>
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<td>Subjective beliefs: $\sigma_{t+1}^{AEX}$</td>
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<td>Lack of confidence in sav. acc. return estimate</td>
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<td>0.24</td>
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<td>Experimental tasks difficult</td>
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<td>Experimental tasks obscure</td>
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<td>0.27</td>
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<td>Financial wealth $\in (30000 , \text{€}, \infty)$</td>
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<td>30 &lt; Age $\leq 50$</td>
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<td>50 &lt; Age $\leq 65$</td>
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Discussion and conclusions
Results

- Coefficient estimates
Results

- Coefficient estimates
- Average partial effects of regressors
Results

- Coefficient estimates
- Average partial effects of regressors
- Support of the indices
Results

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- Graphs of participation probabilities (3-D and slices thereof)
Results

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- How far do we get with less specialised data?
Results

- Coefficient estimates
- Average partial effects of regressors
- Support of the indices
- Graphs of participation probabilities (3-D and slices thereof)
- Robustness
- How far do we get with less specialised data?
- Can classical measurement error explain the patterns?
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<td>Financial wealth $\in (10000 \text{ €}, 30000 \text{ €}]$</td>
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<td>7.87</td>
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<td>21.52</td>
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<td>50 $&lt;$ Age $\leq$ 65</td>
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<td>6.51</td>
<td>5.32</td>
<td>15.21</td>
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<tr>
<td>Age $&gt; 65$</td>
<td>4.64</td>
<td>6.26</td>
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<td>15.54</td>
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## Average partial effects

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<tr>
<td>Subjective beliefs: $\mu_{t+1}^{AEX} - \mu_{t+1}^{sav. acc.}$</td>
<td>0.032</td>
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<tr>
<td>Subjective beliefs: $\sigma_{t+1}^{AEX}$</td>
<td>-0.012</td>
<td>.</td>
<td>-0.012</td>
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<tr>
<td>Risk aversion</td>
<td>-0.041</td>
<td>.</td>
<td>-0.041</td>
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<tr>
<td>Absolute difference between belief measures</td>
<td>.</td>
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<td>-0.020</td>
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<tr>
<td>Lack of confidence in AEX return estimate</td>
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<td>-0.015</td>
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<tr>
<td>Lack of confidence in sav. acc. return estimate</td>
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<td>-0.006</td>
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<td>Experimental tasks difficult</td>
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<td>-0.019</td>
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<tr>
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<td>.</td>
<td>-0.011</td>
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<tr>
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<td>0.101</td>
<td>0.030</td>
<td>0.103</td>
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<tr>
<td>Financial wealth $\in (30000 , €, \infty)$</td>
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<td>0.153</td>
<td>0.369</td>
</tr>
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<td>0.014</td>
<td>0.222</td>
</tr>
<tr>
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<td>0.038</td>
<td>-0.034</td>
<td>0.003</td>
</tr>
<tr>
<td>Net income missing</td>
<td>-0.053</td>
<td>0.009</td>
<td>-0.045</td>
</tr>
<tr>
<td>High education</td>
<td>0.010</td>
<td>0.087</td>
<td>0.097</td>
</tr>
<tr>
<td>$30 &lt; \text{Age} \leq 50$</td>
<td>0.088</td>
<td>-0.054</td>
<td>0.034</td>
</tr>
<tr>
<td>$50 &lt; \text{Age} \leq 65$</td>
<td>0.073</td>
<td>-0.010</td>
<td>0.066</td>
</tr>
<tr>
<td>Age $&gt; 65$</td>
<td>0.021</td>
<td>0.019</td>
<td>0.039</td>
</tr>
</tbody>
</table>
Joint density of the two indices
Predicted probability to hold risky assets
Predicted probability to hold risky assets

- Measurement error index at 10% quantile
- Measurement error index at 90% quantile
Robustness

- Exclude transaction cost proxies – interactions not due to wealth only?
Robustness

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Robustness

- Exclude transaction cost proxies – interactions not due to wealth only? ✓
- Mean beliefs only – interpretable scale
Robustness

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Robustness

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- Mean beliefs only – interpretable scale ✓
- “Kitchen sink” – what about the other extreme?
Robustness

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Robustness

- Exclude transaction cost proxies – interactions not due to wealth only? ✓
- Mean beliefs only – interpretable scale ✓
- “Kitchen sink” – what about the other extreme? ✓
- Drop people with missing wealth
Robustness

- Exclude transaction cost proxies – interactions not due to wealth only? ✓
- Mean beliefs only – interpretable scale ✓
- “Kitchen sink” – what about the other extreme? ✓
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Robustness

- Exclude transaction cost proxies – interactions not due to wealth only? ✓
- Mean beliefs only – interpretable scale ✓
- “Kitchen sink” – what about the other extreme? ✓
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- Philips instead of AEX – not dependent on precise belief object?
Robustness

- Exclude transaction cost proxies – interactions not due to wealth only? ✓
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- Drop people with missing wealth ✓
- Philips instead of AEX – not dependent on precise belief object? ✓
- Disaggregated risk aversion measures
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- Alternative calculation of belief moments
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- Alternative calculation of belief moments ✓
Could it just be classical measurement error?

If so,

1. linear combinations of our two belief measures should lead to higher explanatory power than any one measure by itself
Explanatory power of different linear combinations of the two belief measures for stockholdings
Could it just be classical measurement error?

If so,

1. linear combinations of our two belief measures should lead to higher explanatory power than any one measure by itself
   → Maximum very close to full weight on ball allocation task

2. average stock market participation should be the same regardless of measurement error in beliefs
   → Level higher for low values of measurement error
Could it just be classical measurement error?

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1. linear combinations of our two belief measures should lead to higher explanatory power than any one measure by itself
   \(\rightarrow\) Maximum very close to full weight on ball allocation task

2. average stock market participation should be the same regardless of measurement error in beliefs
   \(\rightarrow\) Level higher for low values of measurement error
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1. linear combinations of our two belief measures should lead to higher explanatory power than any one measure by itself
   \[\rightarrow\] Maximum very close to full weight on ball allocation task

2. average stock market participation should be the same regardless of measurement error in beliefs
   \[\rightarrow\] Level higher for low values of measurement error

\sum\hspace{1cm}\text{Patterns not just driven by carelessness in stating beliefs}
Discussion and Conclusions

- Subjective expectations data not in high regard among economists:
Discussion and Conclusions

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  - Pervasiveness of measurement error
Discussion and Conclusions

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  - Low explanatory content for decisions on average
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- Heterogeneous decision rules potentially explain both facts
Discussion and Conclusions

- Subjective expectations data not in high regard among economists:
  - Pervasiveness of measurement error
  - Low explanatory content for decisions on average
- Heterogeneous decision rules potentially explain both facts
- Have shown how individual-level measurement error in beliefs can be used to uncover such heterogeneity