Ambiguity attitude:  
A review of empirical findings

prepared for:  
Blackwell Handbook of Behavioral Decision Making

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Forward looking

Backward looking: taking stock
people’s preference between bets in artificial individual decision situations

⇒ How robust is the evidence on ambiguity aversion
⇒ Sign dependence
⇒ Correlation of ambiguity attitude & risk attitude

...may not be of immediate interest to economics

But:
⇒ fit models/test models of ambiguity attitude
⇒ use models in economic theory


Requires robust understanding of ambiguity attitude
people’s preference between bets in artificial individual decision situations

⇒ How robust is the evidence on ambiguity aversion

⇒ Sign dependence

⇒ Correlation of ambiguity attitude & risk attitude

outside the lab often no isolated one-shot individual decision situation (ecological validity)

⇒ Peer effect/group decisions

⇒ Learning

⇒ Markets ⇒ Sascha Fuellbrunn poster

relevant for economic behavior (external validity)?

⇒ Link ambiguity attitude measurement ⇐ financial, health, etc. behavior outside the lab

⇒ Peter Wakker talk
How robust anyway? (focus on gains only)

Stahl (2012): goal=>study heterogeneity

2 color problem

| Bet on red from risky for $10 vs. Bet on red from ambiguous for $10 | % risky
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>2 color problem% risky</td>
<td>72%</td>
</tr>
<tr>
<td>Bet on black from risky for $10 vs. Bet on black from ambiguous for $10</td>
<td>67%</td>
</tr>
<tr>
<td>Bet on red from risky for $10 vs. Bet on black from ambiguous for $12</td>
<td>49%</td>
</tr>
<tr>
<td>Bet on black from risky for $10 vs. Bet on black from ambiguous for $12</td>
<td>47%</td>
</tr>
</tbody>
</table>

Drops rapidly
How robust anyway? (focus on gains only)

Stahl (2012): goal=>study heterogeneity

3 color problem

- Red: 1/3
- Yellow: ?
- Black: 2/3

Focus on gains only.
How robust anyway? (focus on gains only)

Stahl (2012): goal=>study heterogeneity

<table>
<thead>
<tr>
<th>3 color problem</th>
<th>% risky</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal prize for risky bet and ambiguous bet</td>
<td>56%/55%</td>
</tr>
<tr>
<td>$10 prize for risky bet and $12 ambiguous bet</td>
<td>35%/38%</td>
</tr>
<tr>
<td>$10 prize for risky bet and $15 ambiguous bet</td>
<td>15%/23%</td>
</tr>
</tbody>
</table>

Looks at all decisions (2-color and 3-color):
- 40% of Ss violate consistency, e.g. choose risky for $10, ambiguous for 12$, risky for $15
- variation between 2-color choices and 3-color choices

<table>
<thead>
<tr>
<th>red</th>
<th>yellow</th>
<th>black</th>
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<tbody>
<tr>
<td>1/3</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>2/3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How robust anyway? (focus on gains only)

Stahl (2012): goal=>study heterogeneity

Estimates proportion of types (lots of model assumptions):
EU: 26%
Level-0: 60%
Ambiguity averse: 12%

Concludes: lots of confusion, and a slight (and noisy)
tendency toward ambiguity aversion
How robust anyway? (focus on gains only)

Stahl (2012): lots of confusion, and a slight (and noisy) tendency toward ambiguity aversion

Binmore et al. (2011): wanted to conduct horse race of different ambiguity theories, using 3-color problem

Elicit probability equivalent (Kahn-Sarin, 1988):

<table>
<thead>
<tr>
<th>red</th>
<th>yellow</th>
<th>black</th>
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<tbody>
<tr>
<td>1/3</td>
<td>2/3</td>
<td></td>
</tr>
<tr>
<td>2/7</td>
<td>5/7</td>
<td></td>
</tr>
<tr>
<td>2/9</td>
<td>7/9</td>
<td></td>
</tr>
</tbody>
</table>

Risky bet vs ambiguous bet?
How robust anyway? (focus on gains only)

Stahl (2012): lots of confusion, and a slight (and noisy) tendency toward ambiguity aversion

Binmore et al. (2011): wanted to conduct horse race of different ambiguity theories, using 3-color problem

Elicit probability equivalent (Kahn-Sarin, 1988):

Experiment 1: find little ambiguity aversion

Experiment 2: try harder; change wording; find little ambiguity aversion

Experiment 3: try even harder; change wording; eliminate hedging opportunity by not offering both sides of the bet; find little ambiguity aversion…
How robust anyway? (focus on gains only)

Stahl (2012): lots of confusion, and a slight (and noisy) tendency toward ambiguity aversion

Binmore et al. (2011): find little ambiguity aversion; estimation suggests that people just perceive ambiguous option as 50-50, and some noise that is modestly in the direction of ambiguity aversion

Charness et al. (2011): wanted to study effect of persuasion, 3-color urn

Elicit probability equivalents; find the following proportions
EU: 60%
Ambiguity aversion: 8%
Ambiguity seeking: 12%
Confused: 20%
How robust anyway? (focus on gains only)

What to make of this evidence?
1. Good news! True effects cannot show up in 100% of low powered experiments; file drawer effect, publication bias; doesn’t look like vanishing effect:

Charness et al., 2011
Binmore et al., 2011
Stahl, 2012
Ahn et al., 2011

Butler et al., 2011
Eichberger et al., 2012
Trautmann & Wakker, 2012
Onay et al., 2012
JBDM
Dimmock et al., 2011
Rieger & Wang, 2012
FRL

... find ambiguity aversion
How robust anyway? (focus on gains only)

What to make of this evidence?
1. Good news! True effects cannot show up in 100% of low powered experiments; file drawer effect, publication bias; doesn’t look like vanishing effect
2. Informative!
   • 3-color problem (confusing=>noise?)
   • choice-based (less ambiguity aversion in choice)

Peter, sources?

Trautmann-Vieider-Wakker (2011MS)

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Willingness to Pay in €</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WTP risky</td>
</tr>
<tr>
<td>Choice-ambiguity seeking</td>
<td>11.64</td>
</tr>
<tr>
<td>Choice-ambiguity averse</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 7</th>
<th>CE in €</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CE risky</td>
</tr>
<tr>
<td>Choice-ambiguity seeking</td>
<td>16.73</td>
</tr>
<tr>
<td>Choice-ambiguity averse</td>
<td>14.84</td>
</tr>
</tbody>
</table>

by choice list
How robust anyway? (focus on gains only)

What to make of this evidence?
1. Good news! True effects cannot show up in 100% of low powered experiments; file drawer effect, publication bias; doesn’t look like vanishing effect
2. Informative!
   • 3-color problem (confusing=>noise?)
   • choice-based (less ambiguity aversion in choice)
   • trust issue: control for possibility of deception by having Ss bet on both sides of the bet (mentioned/tested by Charness et al. and Binmore et al.)

Bet on red from risky for $10 vs. Bet on red from ambiguous for $10
Bet on black from risky for $10 vs. Bet on black from ambiguous for $10

Experimenter cannot add mileage to her budget by putting many black balls into the urn
Trust problems in ambiguity elicitation

⇒ Pulford (2008QJEP) showed relevance of trust story, also Dominiak & Duersch (in prep); Chow-Sarin (2002TD)
⇒ there are papers where this problem is not controlled for and could drive aversion to ambiguity
⇒ But: most studies in econ and ψ control for it by having Ss bet on both sides, or let them choose the color to bet on

↓

Note: In neuro often violated, but there it may be even more crucial
⇒ if you think about what the experimenter had in mind rather than thinking about uncertainty
⇒ e.g. Huettel et al. 2006Neuron: different neural signatures for risk and ambiguity (or strategic thinking?)
How robust anyway? (focus on gains only)

Ambiguity aversion more likely than ambiguity seeking

Strength and prevalence depends on task (does not imply context dependent preferences; psy: the person vs. the situation)
Sign-dependence

Applications of ambiguity attitude in economics and finance typically rely on two assumptions

⇒ ambiguity aversion (e.g. to explain too high risk premia)
⇒ ambiguity attitude does not depend on the asset/situation
  • stock market: assets are mixed gambles (gain & losses)
  • insurance (it’s all about losses)
  • auctions (all gain?)

For risk attitude, gain-loss differences widely known (although not uncontested)
Also for ambiguity attitude, less ambiguity aversion/more ambiguity seeking for losses (less well known; Gijs)
Sign-dependence
Sign-dependence


Trautmann-Wakker (2012): two-color problem, bet on each color once: (never, once, twice) ambiguous chosen
Gains: (28, 11, 6)*
Losses: (21, 12, 12)

Baillon-Bleichrodt (2011): find clear evidence for ambiguity seeking for losses through matching probabilities (not so clear ambiguity aversion for gains)
Sign-dependence

⇒ Needs more attention in applications in finance/economics

⇒ Note on neuro: many papers using losses (electric shocks)!?
Correlation risk aversion $\Leftrightarrow$ ambiguity aversion?

Kocher-Trautmann 2010 EI

20 people

Self-select

Auction for ambiguous lottery

Auction for risky lottery

risk aversion = 3.05

Independent risk aversion measurement (6 risky choices)

risk aversion = 3.88

<table>
<thead>
<tr>
<th>Average risk aversion ambiguous auctiona</th>
<th>2.2</th>
<th>2.3</th>
<th>2.9</th>
<th>3.2</th>
<th>3.7</th>
<th>2.6</th>
<th>3.7</th>
<th>3.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average risk aversion risky auctiona</td>
<td>3.5</td>
<td>3.7</td>
<td>3.6</td>
<td>3.7</td>
<td>4</td>
<td>4.5</td>
<td>3.7</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Less ambiguity averse $\Leftrightarrow$ less risk averse?
Strategic setting, many possible confounds.
Correlation risk aversion ⇔ ambiguity aversion?

Finding positive correlation risk/ambiguity aversion:
- (Charness-Gneezy 2003)
- (Bossaerts et al. 2010RFS)

Portfolio decision sure vs. risky
Portfolio decision sure vs. ambiguous → Invest more

Indirect evidence
Correlation risk aversion ↔ ambiguity aversion?

Finding positive correlation risk/ambiguity aversion:
- (Charness-Gneezy 2003)
- (Bossaerts et al. 2010RFS)
- (Butler et al. 2011)
- Abdellaoui et al. 2011AER
- (Laurialo-Levin 2001JBD) ➔ “for losses (risk) only”
- (Lauriola-Levin-Hart 2007OBHDP) ➔ “for subsample”
- (Chakravarty-Roy 2009TD) ➔ “for gains only”
- (Koch-Schunk 2012SBR) ➔ “only if real losses possible”
- Potamitis-Zhang 2007 ➔ “very weak”
Finding positive correlation risk/ambiguity aversion:

- (Charness-Gneezy 2003)
- (Bossaerts et al. 2010RFS)
- (Butler et al. 2011)
- Abdellaoui et al. 2011AER
- (Laurialo-Levin 2001JBD)
- (Lauriola-Levin-Hart 2007OBHDP)
- (Chakravarty-Roy 2009TD)
- (Koch-Schunk 2012SBR)
- Potamitis-Zhang 2007
- …

Finding no correlation risk/ambiguity aversion:

- Cubitt et al. 2012
- Trossbach 2012
- Cohen et al. forthTD (large sample)
- …

Plus many others, and many who do not report it if absent
Correlation risk aversion ⇔ ambiguity aversion?

Some find positive correlation Many find no risk/ambiguity aversion correlation

⇒ Good reasons to believe there is positive correlation
  • cognitive ability link
  • decision style link
  • subjects typically call ambiguous simply “more risky”
  • most evidence is “positive” or “no:” if it were just noise would expect more “negative” as well
⇒ Measurement error reduces effect
⇒ Mechanic design effects (in comparison between CEs)
⇒ Psychological design effects (Brocccoli effect)
Correlation risk aversion $\leftrightarrow$ ambiguity aversion?

Fox-Tversky 1995: wtp for bet with prize $100$; comparative vs. non-comparative treatments

But risky much more affected: +$10!!$

Chow-Sarin 2001 JRU

+$4$ => ambiguous not worse under comparative evaluation!
Correlation risk aversion ⇔ ambiguity aversion?

Halevy 2007, order of presentation

Risky receives higher evaluations if it comes later (more comparative)

Unclear effect for ambiguous

<table>
<thead>
<tr>
<th></th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_1$</td>
<td>7.28</td>
<td>8.90</td>
<td>7.35</td>
<td>10.00</td>
</tr>
<tr>
<td>$V_2$</td>
<td>6.44</td>
<td>6.67</td>
<td>7.65</td>
<td>5.88</td>
</tr>
</tbody>
</table>
Presence of ambiguity makes risk look nicer, maybe this effect is strongest for the most risk averse/ambiguity averse subjects? => will blur the positive correlation

My kids don’t like broccoli; but they hate spinach; hence, if spinach is served (and broccoli), they suddenly ‘like’ broccoli (relief?). The one who hates spinach most, is most relieved when getting broccoli.
Ecological validity:

Peer effects/joint decisions

Learning
Peer effects/joint decisions

Perfect anonymity quite uncommon in typical decision situations outside the lab
• peer effect
• group/joint decision

=> Ecological validity of ambiguity aversion found in individual/anonymous decisions?
Peer effects/joint decisions: Ecological validity of ambiguity aversion?

Peer effects:
Curley, Yates & Abrams 1986OBHDP
Taylor 1995OBHDP
Trautmann et al. 2008JRU
Mutukrishnan et al. 2009MS

More ambiguity aversion if others are observing

Vinogradov 2012: decisions influenced by knowledge of others’ choices
Kocher-Trautmann 2010: people expect others to be ambiguity averse

Suggests effect of expectations about others: may reinforce, or moderate AA

Hayden-Heilbronner-Platt 2010: ambiguity aversion in monkeys => social effect cannot be fundamental
Trautmann-Vieider 2012HbRT: (un)predictable?
Peer effects/joint decisions: Ecological validity of ambiguity aversion?

Peer effects:
More ambiguity aversion if others are observing

Affected by expectations about others: may reinforce, or moderate AA

Groups:
Keller, Sarin, & Sounderpadian 2009JDM (more neutral)
Keck et al. 2011
Charness et al. 2011

Neutrality more convincing?

?
Peer effects/joint decisions: Ecological validity of ambiguity aversion?

Peer effects: More ambiguity aversion if others are observing

Groups:
- no effect
  - Keller, Sarin, & Sounderpadian 2009JDM
- (more neutral)
  - Keck et al. 2011
- more neutral
  - Charness et al. 2011

Affected by expectations about others: may reinforce, or moderate AA

• Each peer-setting is a bit different, and there are many
• What can we learn from behavioral experiments? Measure each possible situation separately?
• Maybe neuro-economics experiments more informative about fundamental social effects on ambiguity preference?
Learning

Theoretical complex, difficult to define updating (see discussion in Etner et al. 2012)
Empirically not so much research yet
Learning

Liu-Colman 2009 JoEP, 2-color problem:
- single bet vs. 100 bets (from same urn, reset after each draw)
- prize higher for ambiguous urn

or nothing if your guess is wrong. If you choose Urn 2, then the computer resets the balance of red and green balls each time before you guess the color and draw a ball. You will win NT 600 each time your guess is right or nothing if your guess

<table>
<thead>
<tr>
<th>Single choice</th>
<th>Repeated choice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urn choice</td>
</tr>
<tr>
<td></td>
<td>R</td>
</tr>
<tr>
<td>R</td>
<td>29</td>
</tr>
<tr>
<td>A</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
</tr>
</tbody>
</table>

Approximate indifference for 100 choices

Ambiguity aversion in single choice despite higher prize ambiguous
Learning

Liu-Colman 2009 JoEP, 2-color problem:
• single bet vs. 100 bets (from same urn, reset after each draw)
• prize higher for ambiguous urn

or nothing if your guess is wrong. If you choose Urn 2, then the computer resets the balance of red and green balls each time before you guess the color and draw a ball. You will win NT 600 each time your guess is right or nothing if your guess

“With replacement:”
By betting, you learn the distribution. Initially you accept some ambiguity, then make better bets later.
Learning; anticipating learning opportunity

New composition each round:
“Samuelson’s colleague”-like: unwilling to take one ambiguous gamble, but willing to play many
Choose same color, or each half the time; maybe Raiffa 1961 argument more obvious
Learning

Trautmann-Zeckhauser 2011:
Repeated 2-color problem, equal prize

1) Choose urn risk/ambiguous
2) Bet on color, draw ball (in ambiguous: learn!), win if match
3) Put ball back into the urn (replace)
4) Bet again on color (from same urn), win if match

=> Participants need to anticipate learning
=> They need to learn (switch correctly)

“With replacement:”
By betting, you learn the distribution. Initially you accept some ambiguity, then make better bets later.

Learning; anticipating learning opportunity
Learning

=> Participants need to anticipate learning
=> They need to learn: switch correctly after round 1

<table>
<thead>
<tr>
<th></th>
<th>BASE</th>
<th>REPEAT 10 balls</th>
<th>REPEAT 4 balls</th>
<th>REPEAT (combined)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncertain option chosen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Binomial test, two-sided</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No effect of learning opportunity on choice of urn
Learning

=> Participants need to anticipate learning
=> They need to learn: switch correctly after round 1

Trautmann-Zeckhauser 2011:

No clear evidence for learning

<table>
<thead>
<tr>
<th>Option chosen</th>
<th>Stayed with color predicted in stage 1</th>
<th>Compatible with learning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First color right</td>
<td>First color wrong</td>
</tr>
<tr>
<td>10-ball</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncertain</td>
<td>5/7 (71%)</td>
<td>3/6 (50%)</td>
</tr>
<tr>
<td>Known</td>
<td>8/11 (73%)</td>
<td>9/9 (100%)</td>
</tr>
</tbody>
</table>
Learning

Unlikely that people anticipate the learning opportunities of ambiguous alternatives in repeated-choice settings in the real world.

=> Participants need to anticipate learning
=> They need to learn: switch correctly after round 1

Even if they have some good intuition, not trivial that they draw correct conclusions.

Just 1 repetition, if you choose risky initially, no opportunity to learn (cannot learn to learn).
Ert-Trautmann 2011:

⇒ choice between risk and ambiguous

⇒ first sampling experience
⇒ then choice between risk and ambiguous
Ert-Trautmann 2011:

⇒ choice between risk and ambiguous

⇒ first sampling experience

⇒ then choice between risk and ambiguous

1) More choice of ambiguous
2) Dependence on risky urn switched

Beliefs or specific sample cannot fully explain this pattern; how does attitude change? => Baillon et al. 2011
Learning

Baillon-Bleichrodt-L’Haridon-Keskin-Li 2011

⇒ Look at learning over time when information comes in (observing sample)
⇒ Use more complex methods that allow them to distinguish belief from attitude, and identify component of attitude (ambiguity aversion vs. likelihood insensitivity; Peter’s talk will discuss this method in detail)

IPO, real stock prices, very nice design
Learning

Baillon-Bleichrodt-L’Haridon-Keskin-Li 2011

⇒ Look at learning over time when information comes in (observing sample)
⇒ Use more complex methods that allow them to distinguish belief from attitude, and identify component of attitude (ambiguity aversion vs. likelihood insensitivity; Peter’s talk will discuss this method in detail)

Show that no change in ambiguity aversion/attitude (motivational component), but people become more sensitive to likelihood changes (cognitive component)

Overly sensitive?

⇒ Large literature on learning/belief updating, large literature on ambiguity preferences; suggests fruitful interactions
External validity: link to real work behavior?

Ellsberg-style ambiguity aversion is widely used to explain phenomena in financial markets (theory)

Very limited evidence that Ellsberg-urn type preferences have anything to do with these phenomena
External validity: link to real work behavior?

Some recent negative results:
• Sutter et al. (2012AER), large sample, no clear link to health/financial behavior
• Jamison-Karlan (2012), field experiment Uganda, health
• Dimmock et al. (2011), no link between ambiguity aversion and hypothesized financial behavior

Do more complex elicitation: find some mechanisms (?!)

Simple (couldn’t do complex with kids; in the field); too simple to tap into the relevant processes? Amb. seeking for losses etc.
External validity: link to real work behavior?

But there is some evidence with simple measures:

Rieger-Wang 2012FRL: cross country measurement of ambiguity aversion (simple Ellsberg, trust problem, hypothetical, students), and country-specific equity premium
External validity: link to real work behavior?

Ross et al. (2012): Ellsberg urn preferences in farmers and crop variety choice: (see also Engle-Warnick et al. (2007))

Table 6: MacDonald and Moffitt decomposition of Tobit estimates

<table>
<thead>
<tr>
<th>Variable</th>
<th>Adoption probability</th>
<th></th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (household head)</td>
<td>0.003</td>
<td>0.053</td>
<td>0.004</td>
</tr>
<tr>
<td>Age (household head)</td>
<td>-0.000</td>
<td>0.002</td>
<td>-0.000</td>
</tr>
<tr>
<td>Education (household head)</td>
<td>0.003</td>
<td>0.006</td>
<td>0.004</td>
</tr>
<tr>
<td>Household size</td>
<td>-0.004</td>
<td>0.016</td>
<td>-0.006</td>
</tr>
<tr>
<td>Extension visits</td>
<td>0.073**</td>
<td>0.029</td>
<td>0.100**</td>
</tr>
<tr>
<td>Land</td>
<td>0.025†</td>
<td>0.015</td>
<td>0.035†</td>
</tr>
<tr>
<td>Risk: coin toss</td>
<td>0.007</td>
<td>0.010</td>
<td>0.009</td>
</tr>
<tr>
<td>Risk: urn</td>
<td>-0.005</td>
<td>0.010</td>
<td>-0.007</td>
</tr>
<tr>
<td>Risk: self-assessed</td>
<td>0.001</td>
<td>0.008</td>
<td>0.000</td>
</tr>
<tr>
<td>Ambiguity</td>
<td>0.0145**</td>
<td>0.000</td>
<td>0.020**</td>
</tr>
</tbody>
</table>

Significance levels: †: 10%  *: 5%  **: 1%

Less ambiguity averse: more likely to adopt, and more intensity, of new rice variety

Note 1: risk & amb. not correlated
Note 2: trust issue
External validity: link to real work behavior?

- Some negative results; few clear cut positive results; a few suggestive results
- Methods do not always meet the requirements we would insist on in the lab.
- More evidence needed to establish external validity.
Conclusions

From the point of view of a PhD student in finance/economics who plans to apply ambiguity attitude in some theoretical settings, the following may be relevant:

- lab ambiguity attitude no artifact, but the link to real world behavior is not yet clearly established
- there is more than ambiguity aversion: e.g. ambiguity seeking for losses, correlation between risk and ambiguity attitudes
- are anonymity and one-shot, individual decisions relevant in the setting under consideration?
Cognitive dissonance

Why did the treasurers of conservative Dutch housing corporations invest in highly ambiguous derivatives before the recent crisis?!

Because they are very ambiguity averse as we know from Ellsberg urn experiments!