"Risky Curves, Rotterdam 2014"

1. Zurich for Rotterdam
2. This presentation is based on our recent book, coauthored with Dan Friedman, Mark Isaac, and Duncan James, titled "Risky Curves: On the Empirical Failure of Expected Utility" published in March this year.

The book deals with the broad economic challenge of understanding, explaining and predicting risky choice in various domains of human experience, especially by attributing curved utility or Bernoulli functions to decision makers and estimating these curves.

Following Harry Markowitz, we assume that utility function is just a device for explaining and predicting choices involving risk. Predictive content—out of sample and out of context, and not just in laboratory—is essential to value of a theory. No science, economics included, can be based on theories without significant predictive power.

3. To summarize our argument:
   - From Daniel Bernoulli (1738) to Von Neumann Morgenstern (1943), curved utility (or Bernoulli) functions, combined with dispersion outcomes as the measure of risk, have been used to model, and try to understand and predict risky choices.
   - This idea of expected utility is widely accepted in the field; theorists devise new parameterized curves (such as CPT); experimenters devise protocols to elicit data and estimate the Bernoulli functions.
   - However , the empirical harvest of this vast endeavor has been meager.
   - There is little stability in parameters outside the fitted context;
   - Power to predict out-of-sample and out-of-context has been poor-to-nonexistent;

- There have been few convincing victories over naïve alternatives.
- This theory has yielded surprisingly little insight into phenomena outside the lab such as insurance, security, labor, forex markets, gambling, business cycles, etc.

In the 15 minutes I have, I shall try three very quick reviews—listing really—of:

- the research through 1950s;
- measurement of individual risk preferences; and
- aggregate level evidence from the field;

and then finish by

- raising some doubts about scientific content of this approach;
- not being sure of the way forward, I mention just three possibilities:
    - Alternative meanings/measures of risk;
    - Second, after Stigler/Becker 1977, look for explanatory power in decision makers' observable opportunity sets, real options, and net pay-offs, instead of looking for explanations in unobserved curved Bernoulli functions;
    - Third, current work in evolution, learning theory, and neuro-economics may yield new insights into risky choice but it is too early to tell.

4. First, a few words on research through 1950s.
    - Bernoulli proposed log utility function to explain St. Petersburg paradox;
    - Jevons linked Bernoulli to decreasing marginal utility; and
    - Soon after, ordinal paradigm came to fore in the early part of the 20th century.
    - In 1943, John Von Neumann and Oskar Morgenstern, in their book *Theory of Games and Economic Behavior,* axiomatized choice theory, and provided a general empirical procedure to

estimate Bernoulli functions of individuals from choice data over lotteries.

5. Their work was a challenge to economists to furnish empirical content to choice theory. And since then, paradoxically, neoclassical ordinal and Von Neumann's cardinal utility have co-existed in graduate textbooks and seminars.

Von Neumann/Morgenstern's challenge was taken up almost immediately with attempts to specify and measure individual risk preferences.

6. First came the freehand drawing proposals of Friedman and Savage, and Markowitz.
As you can see, the left shows the proposal of Friedman and Savage with 2 points of inflexion. Markowitz, dissatisfied with that, proposed a utility function with 3 points of inflection shown to the right.

7. This was followed by the empirical task of mapping Bernoulli functions. In the earliest, Mosteller and Nogee 1951 concluded that;

- Maximization of expected utility is not an unreasonable description of data.
- Noticed inconsistency in behavior relative to VNM,
- Little support for Friedman and Savage;
- However, the Harvard students were found to be more "conservative" or concave, compared to national guard which were found to be convex,
- 8. and here's an example of the Bournoulli functions they sketched from the data.

9. Ward Edwards' studies that followed concluded

- Another model, that subjects choose so as to maximize expected utility, failed to predict choices successfully (10).

11. Grayson 1960, a Howard Raiffa PHD student, examined drilling decision by oil and gas operators, and here are some of the results. You can decide whether they are concave – risk averse or risk (11). There were many more, but without consistency.

12. These freehand exercise were followed by theoretical attempts to parametrize utility functions by Pratt, Diamond, Rothschild, and Stiglitz through the 1960s and 70s, and almost all subsequent work on the Bernoulli function estimation used the parametric approach. The question is to what extent did these elicitations yield estimates of a person's propensity to choose under risk which could be depended on to make useful predictions.

13. In the time available, I can only list the major categories of the massive and fast growing literature on elicitation of risk preferences

- Certainty equivalents
- Lottery choice menu (Binswanger)
- Auctions
- Becker-DeGroot-Marshak procedure
- Holt-Laury procedure
- Pie Charge procedures
- Physiological measurements of hormones and effect on risk
- Payment methods
- Becker-DeGroot-Marshak vs. auctions
- Small and large stakes
- Problem solving ability
- Perception of institutions
- Heuristics

14. Each one of these categories has a very large literature behind it but, given the time constraints, , I shall skip forward to a summary slide (24).

- Different ways of eliciting risk parameters in cash-motivated controlled experiments yield different results.
- Little evidence that the applications of expected utility and its many variations, based on elicited preferences, predict individual choice better than naïve alternatives.

Of course we know that estimation procedures applied to any choice data necessarily yield some risk coefficient; the question is whether they exhibit stability and predictive power outside the sample and outside the contexts.

We think it is reasonable to conclude that, perhaps the failure to find stable results *is* the result of this literature.

However, just because we cannot use the theory to predict in individual choices doesn't mean it may not be useful at the aggregate level. In the aggregate socio economic phenomena we might still find some consilience across macro domains.

25. So, we look at
- Health,
- medicine,
- sports,
- illicit drugs
- Gambling
- Engineering
- Insurance
- Real estate
- Bond markets
- Stock markets
- Uncovered interest rate parity in foreign exchange markets
- Equity premium puzzle, and
- Aggregate model calibrations in domains of
  - Labor markets

- Social/unemployment insurance
- Central bank reserves

26. Again, in available time, I cannot go into details of these individual literatures but it is fair to say that in fields of drug addiction, medicine, health, and engineering (27) , risk means a possibility of loss, injury or harm (where aversion to risk is matter of definition, not empirical measurement).

28. In Gambling, risk means the same thing. Under dispersion measure, no curved Bernoulli function is able to explain the small sizes of most gambles people take.

29. 30. In insurance and bond markets, risk has little to do with the dispersion of outcomes. It's the loss or harm, the meaning of risk that is dominant here.

31. Dispersion meaning of risk after Markowitz has become prominent in stock markets. According to the crowning jewel of finance, the CAPM, risk aversion combined with curved Bernoulli functions yield linear, or at least monotonic risk-return relationship. Yet in this most intensively empirical literatures in all aspects of economics, empirical valididity of this theorem is not even debated anymore: As you can read from Fama and French: "Our tests do not support the most basic predictions the Sharpe Lintner Black model that average stock returns are positively related to market betas, betas being the measure of risk.

32. In Brealey and Myers, the best known MBA book in finance: "There is no doubt that the evidence on the CAPM is less convincing than scholars once thought. But it will be very hard to reject the CAPM beyond all reasonable doubt."

33. Diversification is the best free lunch in economics. Yet its implications have not been held up in the empirical data in the macro domains of household portfolios.

34. Uncovered interest parity in foreign exchange markets does not hold up.

35. Equity premium puzzle - as many of you know - to reconcile the data and theory, you need risk coefficients which are different by an order of magnitude or more;

36. Aggregate model calibrations - Chetty's examination of 33 sets of wage and income elasticities imply the risk of coefficients in the range of 0.15-1.78 which is a factor of about 12.

37. Summary of aggregate level evidence:

- The hope that curved Bernoulli functions, combined with the dispersion concept of risk, might yield insights into social-economic phenomena in the field waits to be fulfilled.
- Surprsingly, there is little aggregate level insights or consilience across domains populated by the same agents in various kinds of markets have been achieved.
- Research literature often assumes such functions but attempts to tie the resulting models to data often lead to wildly different, and mutually inconsistent implied innate preferences in specified populations.

38. So, what could we do next? Estimated risk coefficients vary from 0.15 to 14 (two orders of magnitude) for the same population. Perhaps we should think about an alternative way of understanding risky choice.

- Should we look for alternatives of risk as I mentioned earlier. Most laymen think of loss – injury, harm. Not dispersion. And yet, the dominant feature of risk in certain parts of

finance and economics literature has been dispersion measures of risk.

- Second, we might look for explanatory power in observables: the decision maker's opportunity sets, real options, and net pay-offs, instead of unobserved Bernoulli functions.

39. In the Phlogiston, as you probably remember from high school chemistry, science was trapped for almost 100 years in its own eddy currents. Phlogiston was suggested as an explanation for combustion and only after 100 years of attempts, it turned out that it was completely wrong. It was Lavoisier's oxidation theory that ultimately won out but it took a long time.

40-41. What is the meaning of risk? The loss meaning of risk sometimes can overlap with the dispersion meaning of risk but not necessarily. As you can see in these charts, for uniform distributions there is a .71 correlation between loss measure of risk and the standard deviation. But for beta distributions there's no correlation between the two. They are very different measures of risk.

42. Let us think of the alternatives:

- Prospect theory is not an alternative because it is just another variant of EU with lots of free parameters and including free parameters for a probability curve w;
- This flexibility supplemented by an unmodeled phase of editing and adjustment allows prospect theory to rationalize risky-choice data in a sample. But there is no evidence of out-of-sample power to predict.

43-44. In 1977 Stigler and Becker suggested holding preferences constant across people and time and focus on how contexts or opportunity sets that we can observe;

Risk aversion and risk preference is the first in their list of future applications, and that agenda can now be implemented, by shifting our focus to the observables conditions of decisions as explanatory variables.

44. Risks change opportunity sets of decision makers in observable ways, yielding testable predictions versus unobservable Bernoulli Functions and probability weights;
We think this is an area for rich applications of real options as argued in Dixit and Pindyck's book published almost 20 years ago.

45. Here are some examples of concave revealed preferences from linear intrinsic preferences:

- When concavity arises from certain frictional costs;
- Some tournament type incentives Or 46. Bailouts can give you convex revealed preferences from linear preferences;
- 47-48. You can get more complicated shapes as have been shown by Marshall and Masson and Chetty.

49. So, using observable opportunity sets and real options, in our opinion, is a more promising way to understand risky choice. Reliance on curved Bernoulli functions to understand risky choice has not yet paid dividends either at individual levels or at aggregate levels.

(50)After seventy years or three centuries (depending on when you start counting time) of pursuit of curved Bernoulli functions we believe that it's time for us to explore seriously of some alternative approaches. (51).

Thank you. (52)