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Asset Integration and Attitudes to Risk: Theory and Evidence

by

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ABSTRACT. Measures of risk attitudes derived from experiments are often questioned because they are based on small stakes bets and do not account for the extent to which the decision-maker integrates the prizes of the experimental tasks with personal wealth. We exploit the existence of detailed information on individual wealth of experimental subjects in Denmark, and directly estimate risk attitudes and the degree of asset integration consistent with observed behavior. The behavior of the adult Danes in our experiments is consistent with partial asset integration: they behave as if some small fraction of personal wealth is combined with experimental prizes in a utility function, and that this combination entails less than perfect substitution. Our subjects do not perfectly asset integrate. The implied risk attitudes from estimating these specifications imply risk premia and certainty equivalents that are *a priori* plausible under expected utility theory or rank dependent utility models. These are reassuring and constructive solutions to payoff calibration paradoxes. In addition, the rigorous, structural modeling of partial asset integration points to a rich array of neglected questions in risk management and policy evaluation in important field settings.

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Debate surrounding theories of decisions under risk and uncertainty has renewed interest in the arguments of the utility function over event outcomes. The local measure of risk aversion proposed by Arrow [1971] and Pratt [1964] for expected utility theory (EUT) is based on terminal wealth being the argument. However, there is nothing in the axiomatic foundation of EUT that requires one to use terminal wealth as the argument: indeed, Vickrey [1945] used income instead of terminal wealth; von Neumann and Morgenstern [1944; p. 15-20] [1953; p. 15-31] were agnostic; and Luce and Raiffa [1957; ch.2] discussed alternatives such as scalar amounts of terminal wealth or income or, alternatively, vectors of commodities. Arrow [1964], Debreu [1959; ch.7] and Hirshleifer [1965][1966] developed models in which the arguments of utility functions are vectors of contingent commodities.

The choice of arguments of the utility function can have important consequences for the inferences one can plausibly draw from empirical estimates of risk attitudes. Many economics experiments present participants with gambles over relatively small stakes and find that such gambles are frequently turned down in favor of less risky gambles with smaller expected values. If the argument of the utility function is terminal wealth, then some patterns of small stakes risk aversion have implausible implications for preferences over gambles where the stakes are no longer small. One example from Rabin [2000] is that the expected utility of terminal wealth model implies that an agent who turns down a 50/50 bet of losing $100 or gaining $110, at all initial wealth levels between $100 and $300,000, will also, at initial wealth of $290,000, turn down a 50/50 bet with possible loss of $2,000 even when the gain is as large as $12 million. However, if the argument of the utility function is not terminal wealth, but rather the stakes offered in the gamble itself, or some other non-additive aggregation of initial wealth and the stakes, implications of this assumed pattern of small stakes risk aversion are no longer ridiculous (implausible) risk aversion (Cox and Sadiraj

[2006]).

Given the importance of understanding the arguments of the utility function, the absence of empirical tests is remarkable. We present evidence from a unique data source that allows us to confront the question of whether wealth is indeed an argument of the utility function, and whether integration of wealth with income in risk preferences is full, partial or null, when agents are making choices over gambles with more modest stakes.[1] We combine field experimental data on lottery choices from a sample of the Danish population and individual-level information on "personal wealth" from a confidential database maintained by Statistics Denmark. Using these data we are able to *identify a measure of personal wealth for the very same individuals that participated in standard experimental tasks*. This allows us to explore theoretical specifications that measure the extent to which individuals integrate their wealth with the prizes on offer in the experimental lottery tasks.

We find no support for the terminal wealth model. Our subjects behave as if they integrate only a small fraction of their personal wealth with the lottery prizes they are asked to make choices over. In our preferred specification they do not behave as if this adjusted personal wealth is a perfect substitute with the money from lottery prizes. The estimated utility function reflects what we call "partial asset integration": it *does* exhibit low-stakes risk aversion of the type in the earlier example *and* has plausible risk attitudes over large stakes.

In section 1 we briefly review the theoretical literature on the arguments of utility over

[1] The closest data source is compiled by Schechter [2007], based on a sample of 188 rural Paraguayan households that made one lottery choice in an experiment and provided self-reported measures of daily income. She focuses on the integration of experimental payoffs with daily income on the day of the experiment, assuming it is all consumed on that day, and also with the integration of experimental payoffs with the present value of that daily income when inter-day savings are allowed. In each case she only considers *full asset integration*, in which experimental payoffs are added to daily income, and the intertemporal utility function is linear in current and future utility. She also reports the availability of a measure of household physical wealth, given by the self-reported value of land, animals and tools. She does not report any measures of financial wealth, which may have been negligible for this population.

vectors of outcomes and implications for the measurement of risk attitudes. We note that the debate is not really about expected utility theory being a "dead parrot" or not (Rabin and Thaler [2001]), since calibration issues apply to a wide range of decision models. Moreover, extreme assumptions about the nature of asset integration can be seen as special cases of a more flexible specification that admits both wealth and experimental income as arguments of some non-linear function. These results are not new, but they are not widely known. They are important because they serve up a menu of theoretically coherent alternatives to the extreme, "all or nothing" assumptions about asset integration that are often subsumed in the literature.

In section 2 we describe the data we have assembled from a combination of experimental tasks and links to Danish Registry databases maintained by Statistics Denmark. The sense in which our measure of "personal wealth" deserves quotation marks is explained. It does not include everything that a theorist might want to see in there, such as the present subjective value of human capital, nor does it include every category of financial wealth. On the other hand, it is arguably the most comprehensive wealth measure available to those who are really interested in testing the theories of decision under risk. We also examine the robustness of our findings to alternative measures of wealth, such as household wealth rather than personal wealth.

In section 3 we present the structural model and econometric assumptions used to evaluate the extent of asset integration observed in our data, and implications for risk attitudes. Section 4 presents estimates and implications. Section 5 outlines some issues that arise in the general case in which experimental choices and non-experimental choices are evaluated jointly. Section 6 draws conclusions.

1. Theory

A. Cacophony of Calibration Critiques

Some seemingly plausible patterns of small-stakes risk aversion can be shown, through concavity calibration arguments, to have implausible implications for large stakes gambles under the terminal wealth specification, where initial wealth and income are integrated perfectly.[2] Alternative empirical identifications of small-stakes patterns have implausible large-stakes implications for models defined on income, in which there is no integration of wealth with income.[3] A different type of (convexity) calibration analysis applies to models with nonlinear probability transformations.[4] From this literature, the theories that are now known to be subject to calibration critique include expected utility theory, the dual theory of expected utility (Yaari [1987]), rank dependent utility theory (Quiggin [1982]), cumulative prospect theory (Tversky and Kahneman [1992]), and weighted utility and betweenness theories (Chew [1983] and Dekel [1986]).

There are two types of calibration critique that one needs to be cognizant of: we refer to these as "payoff calibration" critiques and "probability calibration" critiques. We consider the implications of the payoff calibration critiques. Within that category of critiques, the same risky (income) lottery choices can have quite different implications depending on the extent to which wealth is integrated with income in risk preferences. This is our principal focus.

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[2] See Hansson [1988], Rabin [2000], Neilson [2001] and Safra and Segal [2008] for concavity calibrations of terminal wealth models.

[3] See Cox and Sadiraj [2006], Rieger and Wang [2006] and Rubinstein [2006] for payoff calibrations of income models.

[4] See Cox and Sadiraj [2011] and Cox, Sadiraj, Vogt, and Dasgupta [2010] for probability calibrations of models with nonlinear probability transformations.

B. Partial Asset Integration within EUT

We develop our analysis for a class of expected utility models that includes as special cases models with full asset integration (FAI), models with no asset integration (NAI), and models with partial asset integration (PAI). Models with full asset integration are possibly subject to the payoff calibration critique of Hansson [1988] and Rabin [2000]. Models with no asset integration or partial asset integration are possibly subject to the payoff calibration critique of Cox and Sadiraj [2006] and Rieger and Wang [2006], depending on specific functional forms and parameter estimates. Rather than engage in *a priori* arguments or thought experiments about paradoxes of risky choice, we develop a general theoretical model and let real data do some "real talking."

Cox and Sadiraj [2006] discuss the expected utility of initial wealth and income model with utility functional

$$\int u(w, y)\, dG = E_G\,(u(w, y)), \tag{1}$$

where G is an integrable probability distribution function and u is a utility function of initial wealth w and income y. We refer to this as the PAI-EUT model. Two standard models included in the PAI-EUT model are the expected utility of terminal wealth model with full asset integration (FAI-EUT), for which $u(w, y) = \nu(w+y)$, and the expected utility of income model with no asset integration (NAI-EUT), for which $u(w, y) = \varphi(y)$.[5] These two standard models are polar cases in the class of models of PAI.

We begin with a quasiconcave utility function u(w, y) defined over money payoff in the lab, y, and a measure of wealth, w. In a typical experiment subjects' payoffs are paid in amounts of cash that may not be a perfect substitute for outside the laboratory wealth because of differences in

[5] Any utility function of the form $u(w,y) = \varphi(y) + h(w)$ would exhibit the same preferences over income y.

liquidity and transaction costs. For example, $100 in housing equity is not a perfect substitute for $100 in cash received from participation in an experiment. Therefore, we consider the possibility that money payoffs in an experiment and wealth outside the laboratory may not be perfect substitutes. However, the risk preferences will have convex upper contour sets, since we assumed that the utility function is quasiconcave.

If w and y are not perfect substitutes, there is a need to distinguish ordinal preferences for imperfect substitutes from cardinal preferences over risk. Following Debreu [1976; p.122], for any continuous concave representation of preferences over imperfect substitutes there exists a least concave function u*. All other representations of the same preferences can be written as concave positive monotonic transformations of u*. For homothetic preferences the least concave representation is the degree one homogenous representation. As usual, we say that agent A is more risk averse that agent B if u^A is a concave transformation of u^B.

C. Parametric Structure

A Constant Elasticity of Substitution (CES) function is used to aggregate wealth, w; and money payoff m in an experiment. The terminal wealth model is found at one extreme of parameter values and the pure income model at the other. But the real interest is in between these extremes, and the point is to let the behavior of our subjects tell us the extent to which they (behave *as if* they) are integrating wealth with income from the experiment in making their choices.

Assume that all agents have the same ordinal preferences. We begin with studying homothetic preferences. As noted earlier, the least concave function, u* that represents the same ordinal preferences is a homogenous function of degree one. So we use the CES specification

$$v(w, y) = [\omega\, w^{\rho} + y^{\rho}]^{1/\rho} \qquad (2)$$

where w is a measure of individual wealth, y is the prize in the money payoff in the experimental task, ω is a distributive share parameter to be estimated, $\sigma = 1/(1-\rho)$ is the revealed "elasticity of substitution" between wealth and experimental money payoff, and is also to be estimated, and $-\infty < \rho \leq 1$ to ensure that v(.) is quasiconcave. Risk preferences over (w, y) are represented by transformations of this function, and the EUT assumption that objective probabilities are not modified to generate non-additive decision weights. An often used specification of such transformation is the power function

$$U(v) = v^{1-r}/(1-r) \tag{3}$$

where $r \neq 1$ and v is defined by (2). In effect, (2) and (3) define a two-level, nested utility function, where (2) is an "aggregator function" defining a composite good, and (3) is the utility function defined directly over that composite.[6] Thus we can rewrite (3) more compactly as

$$U(w, y) = [(\omega\, w^{\rho} + y^{\rho})^{(1-r)/\rho}]/(1-r) \tag{3'}$$

where $\omega\, w^{\rho} + y^{\rho} > 0$. This generalized CES function blends together full, partial, and null asset integration on (w, y) space with risk preferences on composite good, v(w,y), space.

With these parametric assumptions, the familiar one-dimensional Arrow-Pratt measure of

[6] This power function is unbounded, so it is useful to be clear on the implications for concavity calibration puzzles under FAI and EUT on a bounded or unbounded domain. If the utility function is bounded on (0, ∞) then that is a sufficient condition for implausible risk aversion in large stakes (e.g., Cox and Sadiraj [2008; Proposition 2, p.20]); global small-stakes risk aversion is not needed for this result. It is not a necessary condition. Small-stakes risk aversion over all (0, ∞) is a sufficient condition for the utility function to be bounded (e.g., Rabin [2000; p.1283] or Cox and Sadiraj [2006; p.59, §C.4]); it is not, however, a necessary condition. Being bounded on (0, ∞) is a necessary condition for small-stakes risk aversion over the open interval (0, ∞), but it is not sufficient. An increasing power function is unbounded and hence violates the necessary condition on boundedness; therefore it cannot represent risk attitudes that exhibit small-stakes risk aversion over all (0, ∞). The sufficiency part can be illustrated by considering a CARA function with parameter 0.0003; it is bounded, however the small-stakes risk aversion pattern is not satisfied, since $100 for sure is *rejected* in favor of an equal chance of $210 or $0. Small-stakes risk aversion defined on a finite interval implies nothing at all about the boundedness of the utility function. Finally, small-stakes risk aversion over a *large enough finite* interval is a sufficient condition for implausible risk aversion for large stakes, whether or not the utility function is bounded or unbounded.

relative risk aversion with respect to y, evaluated at w, is then

$$[\ (1-\rho)\omega + r(y/w)^{\rho}\ ]/[\ \omega + (y/w)^{\rho}\ ] \qquad (4)$$

This is clearly a measure of partial risk aversion with respect to experimental income y.[7] Although the utility function we use has two arguments, w and y, it is only y that was random and an object of choice by our subjects. Hence we do not need to consider generalizations of the one-dimensional Arrow-Pratt measure of risk aversion, such as those proposed by Kihlstrom and Mirman [1974], Duncan [1977] and Karni [1979]. On the other hand, (4) is a partial measure of the curvature of (3′) in the direction of experiment payoffs, and embeds two effects which we can easily keep separate with our structural model: the relative risk r from (3) and the elasticity of substitution σ from (2). This measure of partial risk aversion with respect to y varies with w if *neither* of the following holds: $1-\rho = r$ or $\omega = 0$. It increases on w iff $(1-\rho- r)\ \omega > 0$. For $\omega \geq 0$ the ranking of agents with respect to their degree of risk aversion is captured entirely by r, since v(w, y) is by assumption the same for all agents, and this measure of partial risk aversion is then increasing in r. We discuss the need for measures of *multivariate* risk aversion in section 6 if one is to generalize our approach to allow both arguments of the utility function to be random.

Perfect asset integration with the "utility of wealth" EUT model is the special case in which $\omega=1$ and $\sigma = \infty$. Zero asset integration with the "utility of income" EUT model, where income is interpreted tightly to mean the income from this specific experimental choice,[8] is the special case in

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[7] The assumption that agents have the same ordinal preferences is needed only to be able to talk about *comparative* risk attitudes. If we simply want to report an estimate of partial measure of risk, as given by (4), then we need not make this assumption.

[8] This interpretation is "tight" in the sense that one might also consider income from the set of experimental tasks that this binary choice is embedded in, or the income from the whole experimental session. For example, is income the lottery prize in one row of Table 1, the income from the ten choices in Table 1, the income from all four risk aversion sets of choices, or the income from the whole session since there were discounting choices in addition to these lottery choice questions. One could undertake an exactly parallel discussion of partial asset integration within the experimental session, evaluating what might be called "local asset integration" issues. Our focus here is on "global asset integration issues" between the usual

which $\omega = 0$.[9] Our main hypothesis is that subjects integrate experimental prizes with some small baseline level of consumption, which is that $\omega \approx 0$ and $\sigma \gg 0$. For example, Andersen, Harrison, Lau and Rutström [2008; p.600] assumed baseline consumption of 118DK and $\sigma = \infty$ for these subjects.

An alternative approach to allowing for partial asset integration, adopted by Harrison, List and Towe [2007] and Heinemann [2008], is to assume $\sigma = \infty$ and estimate the composite Ω such that $v = \Omega + y$ is employed by the decision-maker using a utility function such as (3). Useful as far as it goes to move away from the pure "utility of income" EUT model, this approach does not address the manner in which experimental prizes are integrated with wealth, which is the focus of our analysis.

2. Data

Our data consist of observations of choice behavior in experimental tasks and wealth data for those individuals. The sample is representative of the adult Danish population as of January 2003. The experimental data are of the standard type, and are described in detail in Harrison, Lau, Rutström and Sullivan [2005]. The wealth data are novel, and involve matching the experimental subjects with data collected by the Danish statistical agency. The matching process, and all statistical analyses with those data, occur "remotely" at the statistical agency, to ensure privacy. However, they may be replicated under certain conditions described below.

A. Experimental Data

Each subject was asked to respond to four risk aversion tasks. Each such task involved a

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interpretations of experimental data and the implications of the calibration critiques.

[9] And, to visualize these intuitively as perfectly complementary Leontief preferences, $\sigma = 0$. Formally, of course, any value of σ would generate the same observed choices if $\omega = 0$ exactly.

series of binary choices, typically 10 per task, using a multiple price list (MPL) design following Holt and Laury [2002].[10] Each subject is presented with a choice between two lotteries, which we can call A or B. Table 1 illustrates the basic payoff matrix presented to subjects. The first row shows that lottery A offered a 10% chance of receiving 2,000 DKK and a 90% chance of receiving 1,600 DKK. The expected value of this lottery, EV^A, is shown in the third-last column as 1,640 DKK, although the EV columns were not presented to subjects. Similarly, lottery B in the first row has chances of payoffs of 3,850 and 100 DKK, for an expected value of 475 DKK. Thus the two lotteries have a relatively large difference in expected values, in this case 1,165 DKK. As one proceeds down the matrix, the expected value of both lotteries increases, but the expected value of lottery B becomes greater relative to that of lottery A.

The subject chooses A or B in each row, and one row is later selected at random for payout for that subject. The general logic behind this test for risk aversion, assuming perfect separation of experimental prizes from personal wealth for now, is that only risk-loving subjects would take lottery B in the first row, and only very risk-averse subjects would take lottery A in the second last row. Arguably, the last row is simply a test that the subject understood the instructions, and has no relevance for risk aversion at all. A risk neutral subject should switch from choosing A to B when the EV of each is about the same, so a risk-neutral subject would choose A for the first four rows and B thereafter.

We undertake four separate risk aversion tasks with each subject, each with different prizes

[10] Andersen, Harrison, Lau and Rutström [2006] examine the properties of the MPL procedure in detail, and the older literature using it. Harrison and Rutström [2008; §1] evaluate the strengths and weaknesses of alternative elicitation procedures for risk attitudes. Each subject made their choices using our iterative MPL procedure, described in Harrison, Lau, Rutström and Sullivan [2005]. This procedure allowed subjects to refine their choices within the 10 percentage point intervals of the initial stage, although here we do not include data from these refinements.

designed so that all 16 prizes span the range of income over which we seek to estimate risk aversion. The four sets of prizes are as follows, with the two prizes for lottery A listed first and the two prizes for lottery B listed next: (A1: 2000 DKK, 1600 DKK; B1: 3850 DKK, 100 DKK), (A2: 2250 DKK, 1500 DKK; B2: 4000 DKK, 500 DKK), (A3: 2000 DKK, 1750 DKK; B3: 4000 DKK, 150 DKK), and (A4: 2500 DKK, 1000 DKK; B4: 4500 DKK, 50 DKK). At the time of the experiments, the exchange rate was approximately 6.55 DKK per U.S. dollar, so these prizes range from approximately $7.65 to $687.

We ask the subject to respond to all four risk aversion tasks and then randomly decide which task and row to play out. In addition, the large incentives and budget constraints precluded paying all subjects, so each subject is given a 10% chance to actually receive the payment associated with his decision.

These choices themselves, and the design of Holt and Laury [2002] in general, are not the immediate basis for our evaluation of the payoff calibration paradoxes. These *choices* allow us to estimate the risk preferences implied by EUT and RDU models, and those *estimates* are then used to evaluate the paradoxes with counterfactual lottery choices. Cox and Sadiraj [2006][2008] illustrate this use of econometric estimates from the published literature.

B. Wealth Data

Wealth data are based on register data from Statistics Denmark. Our data contain economic, financial, and personal information on each individual from relevant official registers. The data set was constructed based on two sources made available from Statistics Denmark and matched with our experimental data: these sources are the Danish Civil Registration Office and the Danish Tax Authorities. All Danish individuals have a unique social security number given at birth, known as the

CPR number, and this number allows us to match data across data sources. The CPR number follows every individual throughout the entire life and all information on an individual is registered on this number.

Individual and family data are taken from the records in the Danish Civil Registration. These data contain the entire Danish population and provides unique identification across individuals and households over time. Each record includes the personal identification number (CPR), name, gender, date of birth, as well as the CPR numbers of nuclear family members (parents, siblings, and children) and marital history (number of marriages, divorces, and widowhoods). In addition to providing extra control variables, such as age, gender, and marital status, these data enable us to identify the subjects that participated in the field experiment described above, as well as creating additional household characteristics.

Income and wealth information are retrieved from the official tax records at the Danish Tax Authorities (SKAT). This data set contains personal income and wealth information by CPR numbers on the entire Danish population. SKAT receives this information directly from the relevant sources: financial institutions supply information to SKAT on their customers' deposits, on financial market assets, on interest paid or received, and on security investments and dividends. Employers similarly supply statements of wages paid to their employees.

The *wealth* variable in our analysis is constructed from data reported by Statistics Denmark that represent net individual wealth. It is constructed as the sum of assets in banks, the market value of domestic and foreign shares, the deposits in mutual funds and the value of domestic and foreign real estate after subtracting domestic and foreign debt. This corresponds to total assets minus total liabilities.

Domestic shares and bonds are reported by the financial institutions as they stand on

December 31st directly to the tax authorities, while real estate values are set by the Danish Tax Authorities for real estate taxation purpose. All foreign assets and debt are self reported. None of our subjects reported any foreign assets or debt to the tax authorities.

Our wealth measure does not include holdings of cash, value of cars, yachts, paintings, equity in privately hold companies, and the market value of shareholder equity in privately held companies or unlisted mutual funds. The wealth measure does not include immaterial assets such as human capital. This means that borrowing for assets such as education is seen as debt without any corresponding assets.

Table 2 provides a tabulation of wealth and its components, and Figure 1 displays most of the distribution. Although we use the definition in Table 2 as our default, one alternative is to use household wealth rather than individual wealth, exploiting further the ability of our data to identify other members of the household of the subject in our experiments. For some subjects there is negative net wealth, reflecting the fact that some assets are not fully accounted for. To take one example, assume that someone borrows 100% against the market value of their house, and that debt is fully reflected at face value. But the taxation office records the value of the house at appraised values, so the familiar downward bias of appraised values, compared to market values, will mean that this individual shows negative net wealth for this component. For all calculations we assume that wealth cannot be negative and essentially truncate it to zero.[11]

Access to these unique data is an important issue, both in terms of the ability of others to replicate our findings and for their ability to extend our analysis. Researchers at authorized Danish institutions can gain access to de-identified micro data provided by Statistics Denmark (SD) through

[11] For purely numerical reasons we truncated to 2.7 kroner to be able to evaluate certain functional transformations. Truncating exactly at zero does not change the results at any significant level.

remote access connections. SD manages most of Danish micro data. The fundamental authorization principle of SD is that data will not be disclosed where there is an imminent risk that an individual person or individual enterprise can be identified. This applies not only to identified data, such as CPR numbers, but also to de-identified data, since such data are usually so detailed that identification can be made.[12]

3. Econometric Model

A. Expected Utility Theory

Although the concerns about implausible risk attitudes under terminal wealth specifications apply to all decision theories that are additive over states, we initially focus on EUT because it is parsimonious. Under EUT the probabilities for each outcome y_j, $p(y_j)$, are those that are induced by the experimenter, so expected utility is simply the probability weighted utility of each outcome in each lottery $i \in \{L, R\}$. Using the expression $U(w, y)$ from (3′), we then have:

$$EU_i = [\, p(y_1) \times U(w, y_1) \,] + [\, p(y_2) \times U(w, y_2) \,] \tag{6}$$

To capture behavioral errors we employ a Fechner specification with "contextual utility," so that we assume the latent index

$$\nabla EU = [(EU_R - EU_L)/\nu]/\mu \tag{7}$$

where ν is a normalizing term described in a moment, μ is the Fechner behavioral error parameter

[12] Access to Danish micro data follows the Act on Processing of Personal Data (in Danish, the Lov om Behandling af Personoplysninger). This requires a notification to the Danish Data Protection Agency whenever data is made available to researchers. Access can only be granted to researchers in authorised environments. Authorizations can be granted to public research and analysts environments (e.g., in universities, sector research institutes and ministries) and to research organizations as a part of a charitable organization. Certain groups in the private sector can get authorization. Only Danish research environments are granted authorization. Foreign researchers from well established research centers can have access to Danish micro data from the on-site arrangement with Statistics Denmark in Copenhagen or Århus. Visiting researchers can have remote access from a workplace in the Danish research institution during their stay in Denmark and under the Danish authorization.

to be estimated, and EU_R and EU_L are the expected utilities of the Right and Left lottery as presented to subjects. The normalizing term ν is defined as the difference between the maximum utility over all of the prizes in that lottery pair minus the minimum utility over all of the prizes in that lottery pair. Thus it varies from choice context to choice context, and normalizes the difference in EU to lie between 0 and 1. This results in a more theoretically coherent concept of risk aversion when one allows for a behavioral error such as with μ (Wilcox [2011]).

The latent index (7), based on latent preferences, is then linked to the observed experimental choices using a standard cumulative normal distribution function $\Phi(\nabla EU)$. This "probit" function takes any argument between $\pm\infty$ and transforms it into a number between 0 and 1 using this familiar function. Thus we have the probit link function,

$$\text{prob(choose lottery R)} = \Phi(\nabla EU) \tag{8}$$

The index defined by (7) is linked to the observed choices by specifying that the R lottery is chosen when $\Phi(\nabla EU) > ½$, which is implied by (8).

Thus the likelihood of the observed responses, conditional on the EUT and utility specifications being true, depends on the estimates of the utility function given the above statistical specification and the observed choices. The "statistical specification" here includes assuming some functional form for the cumulative density function (CDF). Ignoring responses that reflect indifference[13] the log-likelihood for the utility function (3′) would be

$$\ln L(\mathbf{r}, \omega, \rho, \mu; y, \mathbf{X}) = \sum_i [(\ln \Phi(\nabla EU) \times \mathbf{I}(y_i = 1)) + (\ln \Phi(1 - \nabla EU) \times \mathbf{I}(y_i = -1))] \tag{9}$$

where $\mathbf{I}(\cdot)$ is the indicator function, $y_i = 1 (-1)$ denotes the choice of the Option B (A) lottery in risk

[13] In most experiments the subjects are told at the outset that any expression of indifference would mean that if that choice was selected to be played out a fair coin would be tossed to make the decision for them. Hence one can modify the likelihood to take these responses into account by recognizing that such choices implied a 50:50 mixture of the likelihood of choosing either lottery In our experience very few subjects choose the indifference option, but this formal statistical extension accommodates those responses.

aversion task i, ∇EU is defined using the parameters r, ω, ρ and μ, and **X** is a vector of individual characteristics reflecting age, sex, race, and so on.

B. Rank Dependent Utility Theory

One popular alternative to EUT is to allow the decision-maker to transform the objective probabilities presented in lotteries and to use these weighted probabilities as decision weights when evaluating lotteries. If w(p) is the probability weighting function assumed, and one only has lotteries with two prizes, as here, then the expected utility functional (6) is replaced by

$$RDU_i = [\, w(p(y_1)) \times U(w, y_1) \,] + [\, (1-w(p(y_2))) \times U(w, y_2) \,] \qquad (6')$$

where RDU refers to the Rank-Dependent Utility model of Quiggin [1982], $y_1 \geq y_2$, and the remaining econometric specification remains the same. Of course, one then has to specify the functional form for w(p) and estimate additional parameters, but the logic extends naturally.

For our purposes it is sufficient to examine the simplest functional form for probability weighting, the power function with parameter γ,

$$w(p) = p^{\gamma}. \qquad (10)$$

For RDU models that assume no asset integration, Andersen, Harrison, Lau and Rutström [2011a], using a similar data set, evaluated more flexible functional forms due to Prelec [1998], and found that they collapsed to this simple functional form. The log-likelihood then becomes

$$\ln L(r, \omega, \rho, \gamma, \mu; y, \mathbf{X}) = \sum_i [\, (\ln \Phi(\nabla RDU) \times \mathbf{I}(y_i = 1)) + (\ln \Phi(1 - \nabla RDU) \times \mathbf{I}(y_i = -1)) \,] \qquad (11)$$

and we estimate the model with one extra parameter for the probability weighting function.[14]

[14] The context will make it clear whether estimates of r, ω, ρ and μ refer to the EUT model or the RDU model.

4. Results and Implications

A. Basic Results

Table 3 shows initial maximum likelihood estimates of the utility function. In this case we assume that every adult Dane has the same ordinal preferences, to provide a simple starting point. The CRRA coefficient r is estimated precisely, the parameters ω and ρ are less precisely estimated. To see how these estimates can be used to evaluate risk attitudes, focus on the point estimates. We find that the weight attached to wealth is very small, around 3.1%, and that there is considerable substitutability between experimental income and wealth since σ is 1.98. Average net wealth in the estimation sample is 405,025 kroner, and median net wealth is 34,518 kroner, so this implies that individuals behave as if they evaluate experimental income relative to a baseline wealth of 12,638 kroner or 1,075 kroner, respectively. As it happens, it does not matter significantly for our findings whether one uses median or mean wealth, so we focus on median wealth unless otherwise noted.

We can easily reject the hypothesis of FAI. For the hypothesis that $\rho=1$ the *p*-value is less than 0.0001, for the hypothesis that $\omega=1$ the *p*-value is also less than 0.0001, and the same is true for the joint hypothesis that $\rho=1$ and $\omega=1$. Together, the two hypothesis tests are "overkill" of the FAI "parrot" (Rabin and Thaler [2001]). The estimates from Table 3 directly tell us that we cannot reject the null hypothesis of NAI, since the *p*-value of the hypothesis that $\omega=0$ is 0.54.

B. Payoff Calibration Implications for EUT

Using these estimates and the average value of wealth in Denmark we can evaluate the Certainty Equivalents (CE) of a range of lotteries varying in the scale of the stakes. Implausible implications for large stakes can be detected through an extremely low ratio of CE to the Expected

Value (EV).[15]

Table 4 shows implied CE values using the CRRA utility function (3′) and the parameter estimates in Table 3. Let H denote a high prize and L denote a low prize, for H>L obviously. The CE in Table 4 is then the sure amount of money that has the same expected utility to the individual as the lottery that pays H with probability p and L with probability (1-p). In Panel A of Table 4 the CE solves

$$U(w, CE) = p \times U(w, H) + (1-p) \times U(w, L). \quad (12)$$

So this CE solves for risk income in the experiment, and the stakes are chosen to be within the payoff domain in our experiments. In Panel B of Table 4 the CE solves for risky wealth, holding constant the experimental income at zero, and the stakes are chosen to span "life-changing" changes in wealth for most Danes. Formally, for Panel B the CE solves

$$U(w+CE, 0) = p \times U(w+H, 0) + (1-p) \times U(w+L, 0). \quad (13)$$

The smallest ratio of CE to EV in Table 4 is 0.37, and most are much higher: these ratios are hardly implausible in the sense of the term used by Hansson [1988], Rabin [2000], Neilson [2001], Rieger and Wang [2006], Cox and Sadiraj [2006] and Safra and Segal [2008].

Figure 2 displays CE values for a range of lotteries, with varying values of H and L and probability ½. Figure 3 evaluates the traditional Arrow-Pratt measure of relative risk aversion in (4) for the estimated EUT-PAI model, showing modest levels of risk aversion for a wide range of wealth and experimental payoffs.

Using these estimates one can verify that (a) getting 190 with probability ½ and 0 with probability ½ is rejected in favor of getting 75 for sure, for all wealth smaller than 35 million; and (b)

[15] Similar results are obtained with median wealth instead of average wealth. The ratio of EV to CV is slightly lower, but close to those reported here.

the same utility function exhibits plausible risk aversion in Table 4 for large stakes.[16] Under FAI, no EUT-consistent agent can exhibit both (a) and (b).

C. Household Wealth

As a robustness test on these results we also estimate the EUT-PAI model using household wealth as an alternative measure to the personal wealth measure. This does not change the estimates appreciably. The point estimates are $r = 0.69$, $\rho = 0.45$, $\omega = 0.018$, with the implied $\sigma = 1.83$. Standard errors are comparable to those in Table 3 with personal wealth. Average household wealth is 630,251 kroner and median household wealth is 148,750 kroner, so *individuals* behave as if they evaluate experimental income relative to a baseline *household* wealth of 11,344 kroner or 2,677 kroner, respectively. The log-likelihood for this model is -3092.6, compared to the log-likelihood of -3088.3 using individual wealth, so these data very slightly favor the use of individual wealth over household wealth.

D. Probability Weighting

The RDU model estimates with the PAI specification are shown in Panel A of Table 5, and show evidence of slight probability weighting pessimism. Compared to the EUT estimates for the PAI specification, there is less evidence of diminishing marginal utility once the possibility of probability pessimism is allowed for. We can easily reject the assumption that there is no probability

[16] The estimated EUT-PAI specification implies plausible large stakes risk attitudes defined over variations on y, but it is not completely immune to different thought experiments. In particular, because we have employed a CES specification in (2), we know that each "input" is essential, so that the marginal utility of w and y is always strictly positive. So it is no surprise to come up with combinations such as w = 350,000 and y = 200 being on the same indifference curve as w = 525,952 and y = 100 using the point estimates from Table 3. The remedy for these implications, of course, would be a more flexible parametric form for (2) or some semi-parametric specification. Such extensions are beyond the scope of our analysis here.

weighting (γ=1), and this is reflected in the improved log-likelihood with the RDU model over EUT. The extent of probability weighting, and implications for decision weights, are shown in Figure 4. The right panel of Figure 4 shows an example in which the weights on the best and worst prizes are equal to 0.5, and the dashed line then shows the effect of the probability weighting curvature in the left panel. So we see that the weight given to the best prize drops from 0.5 to 0.40, with the weight for the worst prize residually inferred to be 0.6. In terms of PAI, the estimates are similar to those under EUT except that there is slightly more substitutability between wealth and lab payoffs (σ = 2.68 compared to 1.98 under EUT).

Armed with the RDU model, which of course nests EUT, we can undertake some instructive exercises in which we assume either FAI or NAI. Under FAI we expect the estimates to collapse to linear utility functions, with no diminishing marginal utility to explain risk premia, and for the other side of the structural "balloon" to pop out, in the form of greater "pessimism" of the probability weighting function. Indeed, one might argue that this is the clearer implication of worries about payoff calibration in Rabin [2000], despite references there (p. 1288) to the possible role of loss aversion.[17] Under NAI the estimates of Andersen, Harrison, Lau and Rutström [2011a] suggest that we will see very modest probability weighting.

The results are presented in Panels B and C, respectively, of Table 5, and Figure 5, and broadly support these priors. Under FAI the role of diminishing marginal utility as an explanation of the lab risk premium virtually disappears, and probability weighting assumes a much larger role. Figure 5 displays the extent of probability weighting in this case: decision weights on the best prize

[17] It is easy to show that the version of the payoff calibration problem used by Rabin [2000] does not rely on any lotteries having negative prizes. Hence loss aversion might be a sufficient explanation for the specific examples he uses, but it is not a general explanation unless one allows for endogenous reference points (Wakker [2010; ch.8]).

plunge from 0.5 under EUT to 0.21 under FAI. Since there is some evidence for diminishing marginal utility, RDU does not quite collapse to the Dual Theory model of Yaari [1987], although it is moving close to that specification. Under NAI there is a result intermediate between FAI and EUT, as one would expect, and with virtually the same degree of probability weighting as under PAI. The roles for diminishing marginal utility and probability pessimism are each significant.

The overall log-likelihood of the PAI-RDU model is the best of the specifications considered. We can formally reject the FAI hypotheses that $\omega=1$ or $\rho=1$ with *p*-values of 0.0001 or smaller, and again cannot reject the NAI hypothesis that $\omega=0$ for *p*-values less than 0.42. As expected, the log-likelihood of the PAI-EUT model dominates the log-likelihood of the FAI-RDU and NAI-RDU models. Furthermore, the analyst that evaluates lab data assuming NAI and the RDU model would obtain estimates closer to the most preferred PAI-RDU specification than the FAI-RDU specification. This is an important insight, since many analysts will be unable to access wealth data of the quality that we have.

E. Payoff Calibration Implications for RDU

Using the RDU-PAI estimates from Panel A of Table 5, we can again evaluate the ratio of the CE to the EV for a range of low stakes and high stakes lotteries. Using the same lotteries as in Table 4, in Panel A of Table 6 the CE now solves

$$U(w, CE) = w(p) \times U(w, H) + (1-w(p)) \times U(w, L), \quad (14)$$

and in Panel B the CE solves

$$U(w+CE, 0) = w(p) \times U(w+H, 0) + (1-w(p)) \times U(w+L, 0). \quad (15)$$

The smallest ratio of CE to EV in Table 6 is 0.20, and most are much higher, exactly as in Table 4. In general the ratios in Tables 4 and 6 are similar, and just slight smaller in Table 6. Figure 6

provides an overview of a range of CE values in relation to the EV. It is easy to verify that the RDU-PAI model also satisfies the payoff calibration conditions noted earlier for the EUT-PAI model.

5. Generalization

As flexible as our approach is in comparison to the full integration and no integration special cases that have dominated the discussion, it is still something of a "reduced form" approach to the structural question of the joint determination of lab and non-lab choices. In effect, we take the myriad of decisions underlying w to be given, implicitly assuming that all components of w are symmetric in their relation to y. Given the importance of the issue, we sketch several deeper issues that must be addressed as one generalizes our approach.

In general, it need not be the case that there is symmetry with respect to components of w and experimental choices over y. This is immediately problematic when one considers experimental interventions in the field that offer choices over vectors of commodities rather than just money. For example, the experimental provision of a subsidized microinsurance product over one type of stochastic outcome, such as the weather, might be expected to interact with cropping choices differently than family planning decisions or retirement decisions. Closer to our setting, some components of w might be viewed as closer substitutes to experimental income than others. In a related vein, individual wealth might be viewed as a closer substitute to experimental income that the individual is choosing over, and other household wealth as not perfectly fungible with individual wealth. Or we might consider an intertemporal utility function defined over stochastic prizes to be paid today and stochastic prizes to be paid in the future (Kihlstrom [2009] and Andersen, Harrison,

Lau and Rutström [2011b]).[18]

The first issue is to consider multivariate measures of risk aversion. Kihlstrom and Mirman [1974] posed this issue under the restrictive assumption that the ordinal preferences underlying two expected utility functions exhibit the same preferences over non-stochastic outcomes. In this case they propose a scalar measure of total risk aversion that allows one to make statements about whether one person is more risk averse than another in several dimensions, or if the same person is more risk averse after some event than before.

If one relaxes this assumption, which is not an attractive one in many applications, Duncan [1977] shows that the Kihlstrom and Mirman [1974] multivariate measure of risk aversion naturally becomes matrix-valued. Hence one has vector-valued risk premia, and this vector is not "direction dependent" in terms of evaluation. Karni [1979] shows that one can define the risk premia in terms of the expenditure function, rather than the direct utility function, and then evaluate it "uniquely" by further specifying an interesting statistic of the stochastic process. For example, if one is considering risk attitudes towards a vector of stochastic price shocks, then one could use the mean of those shocks.

A closely related literature defines multi-attribute risk aversion where the utility function is defined over more than one attribute. In our case one attribute would be experimental payoffs y and the other attribute would be extra-experimental wealth w. In this context, Keeney [1973] first defined the concept of conditional risk aversion, Richard [1975] defined the same concept as

[18] One might argue that some of these examples of imperfect substitutes derive from the absence of perfect capital markets. For example, in the intertemporal case the existence of perfect capital markets implies the familiar Fisherian (non-)separation theorem. In these cases one would simply restate results in terms of indirect utility functions.

bivariate risk aversion, and Epstein and Tanny [1980] defined it as correlation aversion.[19] There are several ways to extend these pairwise concepts of risk aversion over two attributes to more than two attributes, as reviewed by Dorfleitner and Krapp [2007].

One attraction of the concept of multiattribute risk aversion is that it allows a relatively simple characterization of the functional forms for utility that rule out multiattribute risk attitudes: additivity. One can have an additive multiattribute utility function and still exhibit partial, or single-attribute, risk aversion. Similarly, one can generate results that do not depend on partial, single-attribute risk aversion, but could still depend on multiattribute risk aversion.[20] For multivariate risk aversion one has to check if the Hessian is negative semidefinite under the Kihlstrom and Mirman [1974] definition, but that is not hard for specific numerical ranges. For example, the specific parametric form (3′) can easily be shown to be negative semidefinite. Applying the matrix-valued measures of Duncan [1977] and Karni [1979] would be more involved, of course.

The second broad set of issues is the characterization of behavior when portfolio choices are disaggregated, and when they are integrated with consumption and leisure choices. Within the field of insurance economics, Mayers and Smith [1983] and Doherty [1984] have stressed the confounding effect that allowing for non-traded assets can have on the demand for insurance. For example, if risks in one domain are perfectly correlated with risks in another domain, but traded insurance is only available in one domain, the rational risk-averse agent would tend to "over-insure."

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[19] Several studies note that the core concept appeared as early as de Finetti [1952], but this was written in Italian and we cannot verify that claim.

[20] For example, Abeler, Falk, Goette and Huffman [2011] correctly note that their utility function in effort and payoff generates optimal effort levels that do not depend on risk attitudes towards payoff by itself. But the absence of any role for multi-attribute risk attitudes is due to them assuming an additive two-argument utility function. Hence their inferences from observed behavior about the role of reference points may be confounded. The same issue arises when modeling the tradeoff between leisure and income in the labor supply literature: see equations (1) and (2), each additive, in Farber [2005; p.53].

The entire theory of risk management derives from the complementarity and substitutability of "self protection" and "self insurance" activities with formal insurance purchases identified by Ehrlich and Becker [1972]. The joint modeling of consumption behavior, leisure demand and portfolio choices begun, with non-additive utility functions, by Cox [1975] and Ingersoll [1992] identifies numerous avenues for testable propositions about the unexpected spillover effects of policy interventions. There is also a large literature on the effects of consumption "commitments" on behavior towards risk, starting with Grossman and Laroque [1990] and applied directly to the issue of risk calibration by Chetty and Szeidl [2007].[21] Finally, the partial asset integration approach could provide a rigorous bridge to characterizing the manner in which decision makers employ "mental accounts" to structure the tradeoffs between components of w and y, in the spirit of Thaler [1985]. The hypothesis of mental accounts involves testable statements about the nested nature of substitutability between different components of w and/or y.

In effect, the rigorous evaluation of seemingly arcane calibration puzzles via models of partial asset integration opens up many areas for research that have tended to be neglected.

[21] We do not understand the motivating comments of Chetty and Szeidl [2007; p. 831]: "The canonical expected utility model of risk preferences does not allow for commitments because it assumes that agents consume a single composite commodity. This assumption requires that agents can substitute freely among goods at all times. When some goods cannot be costlessly adjusted, a composite commodity does not exist, and the standard expected utility model cannot be applied." If the lack of substitutability is a matter of direct preferences, such as the imperfect substitutability of Classical and Country & Western music, then it is standard fare of any canonical model worth the name. If the lack of substitutability is a matter of differences in transactions costs, as their later interpretations suggest, then one should work instead in terms of indirect utility functions and simply write out the applicable budget constraints. In neither case do we see why standard theory cannot accommodate the legitimate behavioral modeling of commitments. We stress this since calibration solutions are always presented as if they require some radical change in standard theory.

6. Conclusions

The behavior of the adult Danes in our experiments is consistent with partial asset integration, in the dual sense that they behave as if some (small) fraction of personal wealth is combined with experimental prizes in a utility function, and that the combination entails less then perfect substitution. Our subjects do not perfectly asset integrate.

The implied risk attitudes from estimating these partial asset integration specifications imply risk premia and certainty equivalents under EUT that are *a priori* plausible when confronted with the payoff calibration paradox. Hence our EUT-PAI specification survives the payoff calibration paradox.

Extending the analysis to an RDU model, we find evidence of modest probability weighting and diminishing marginal utility under partial asset integration. Only when one insists *a priori*, and contrary to the inferences we draw about behavior, that decisions are best characterized with full asset integration does probability weighting come to dominate the characterization of risk attitudes over experimental payoffs. Nonetheless, the RDU-PAI specification also survives the payoff calibration paradox.

These are reassuring and constructive solutions to the payoff calibration paradoxes. In addition, the rigorous, structural modeling of partial asset integration points to a rich array of neglected questions in risk management and policy evaluation in important field settings.

Table 1: Typical Payoff Matrix in the Danish Risk Aversion Experiments

Lottery A				Lottery B				EV^A	EV^B	Difference
p	DKK	p	DKK	p	DKK	p	DKK	DKK	DKK	DKK
0.1	2000	0.9	1600	0.1	3850	0.9	100	1640	475	1165
0.2	2000	0.8	1600	0.2	3850	0.8	100	1680	850	830
0.3	2000	0.7	1600	0.3	3850	0.7	100	1720	1225	495
0.4	2000	0.6	1600	0.4	3850	0.6	100	1760	1600	160
0.5	2000	0.5	1600	0.5	3850	0.5	100	1800	1975	-175
0.6	2000	0.4	1600	0.6	3850	0.4	100	1840	2350	-510
0.7	2000	0.3	1600	0.7	3850	0.3	100	1880	2725	-845
0.8	2000	0.2	1600	0.8	3850	0.2	100	1920	3100	-1180
0.9	2000	0.1	1600	0.9	3850	0.1	100	1960	3475	-1515
1	2000	0	1600	1	3850	0	100	2000	3850	-1850

Note: The last three columns in this table, showing the expected values of the lotteries, were not shown to subjects.

Table 2: Individual Wealth in Denmark

Variable	Mean	Median	Std. Dev.
Total assets	**711,817**	**423,898**	**1,103,891**
Real estate	567,140	295,000	771,227
Shares and mutual funds	24,016	0	107,802
Assets in financial institutions	52,068	17,514	88,900
Bonds and mortgages	68,591	0	51,565
Total liabilities	**359,081**	**179,423**	**466,239**
Debt in financial institutions	72,757	9,710	157,332
Bond debt	282,858	0	419,310
Privately issued debt	3,465	0	18,512
Net wealth	**352,536**	**34,518**	**971,761**
Net wealth truncated at zero	**405,025**	**34,518**	**936,130**

Note: Total assets are the value of domestic real estate, shares and mutual funds domestically deposited, assets in domestic financial institutions, domestic bonds and mortgages, and foreign assets. The value of foreign assets is zero for all individuals in the sample. Total liabilities are the value of debt in domestic financial institutions, domestic bond debt, domestic privately issued debt, and foreign debt. The value of foreign debt is zero for all individuals in the sample. All values of domestic shares and bonds are reported by the financial institutions as they stand on December 31st directly to the tax authorities. Values of real estate are set by The Danish Tax Authorities for real estate taxation purpose. All foreign assets and debt are self reported. All values are in 2003 Danish kroner, and for the sample of 250 subjects. As explained in the text, truncation at zero generates essentially the same results as truncation at 2.7 for numerical purposes

Figure 1: Wealth of Individuals

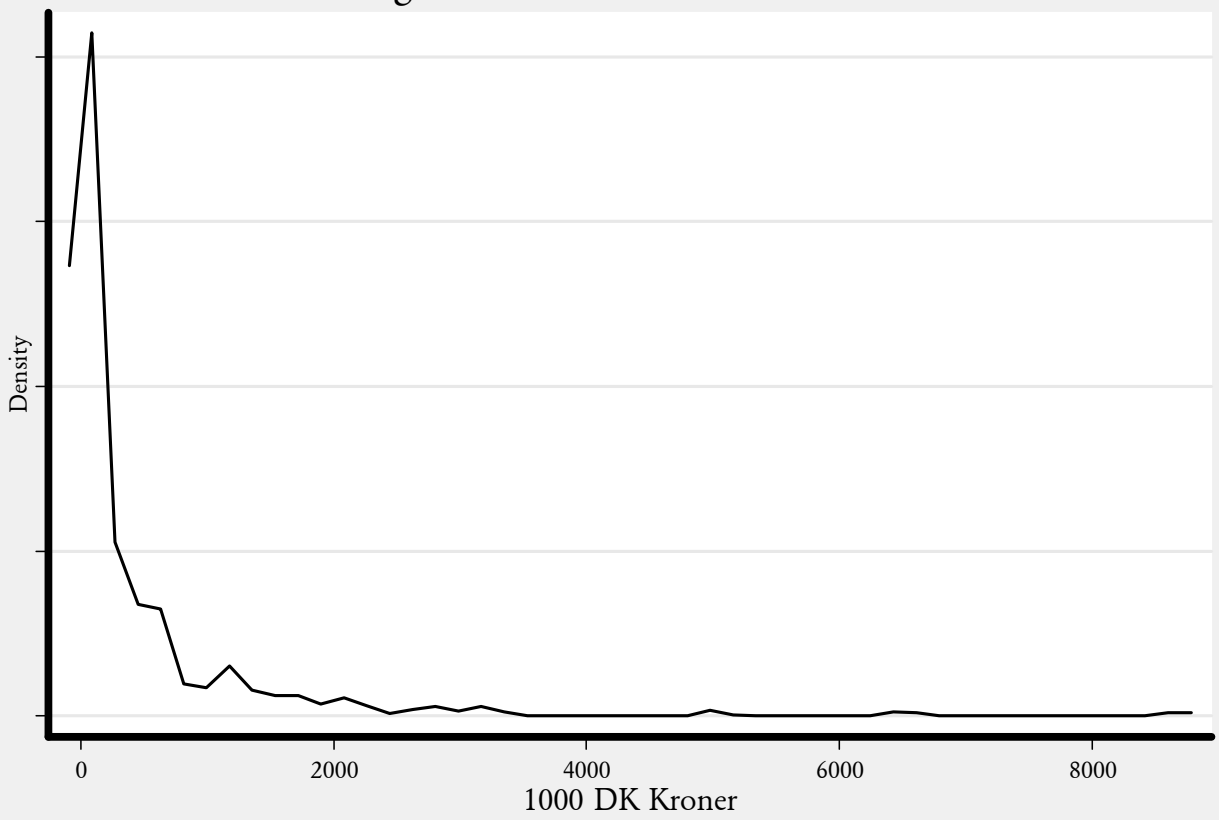


Table 3: Estimates Using EUT-PAI Model

Sample of 250 individuals making 7,524 choices of strict preference

Log-Likelihood = -3088.3

Parameter	Point Estimate	Standard Error	*p*-value	95% Confidence Interval	
r	0.71	0.05	<0.001	0.61	0.81
ρ	0.5	0.26	0.06	-0.02	1.01
ω	0.031	0.1	0.766	-0.174	0.237
μ	0.12	0.006	<0.001	0.11	0.13
		Derived Results			
σ	1.985	1.038	0.056	-0.05	4.019

Table 4: Implied Certainty Equivalents Using EUT-PAI Model

Calculations with average wealth

Large Prize (DKK)	Probability of Large Prize	Small Prize (DKK)	Expected Value (DKK)	Certainty Equivalent (DKK)	Ratio
		A. Risky Lottery in Experiment			
200	0.5	100	150	145	0.97
500	0.5	100	300	254	0.85
1000	0.5	100	550	407	0.74
2000	0.5	100	1050	672	0.64
5000	0.5	100	2550	1350	0.53
5000	0.01	100	149	109	0.73
5000	0.1	100	590	218	0.37
5000	0.3	100	1570	635	0.4
5000	0.7	100	3530	2455	0.69
5000	0.9	100	4510	4018	0.89
		B. Risk Lottery in Wealth			
200	0.5	100	150	149.999	0.999
1000	0.5	100	550	549.82	0.999
5000	0.5	100	2550	2545	0.998
100000	0.5	100	50050	48090	0.96
11000	0.5	10000	10500	10499	0.999
50000	0.5	10000	30000	29672	0.99
100000	0.5	10000	55000	53428	0.97
400000	0.5	10000	205000	182167	0.89
400000	0.01	100	4099	3184	0.78
400000	0.1	100	120070	100092	0.83
400000	0.3	100	200050	175799	0.88
400000	0.7	100	280030	259262	0.93
400000	0.9	100	360010	350938	0.97

Figure 2: Implied Certainty Equivalent of Lotteries
Using Estimates from EUT-PAI Model

Thin line is EV and thick line is CE

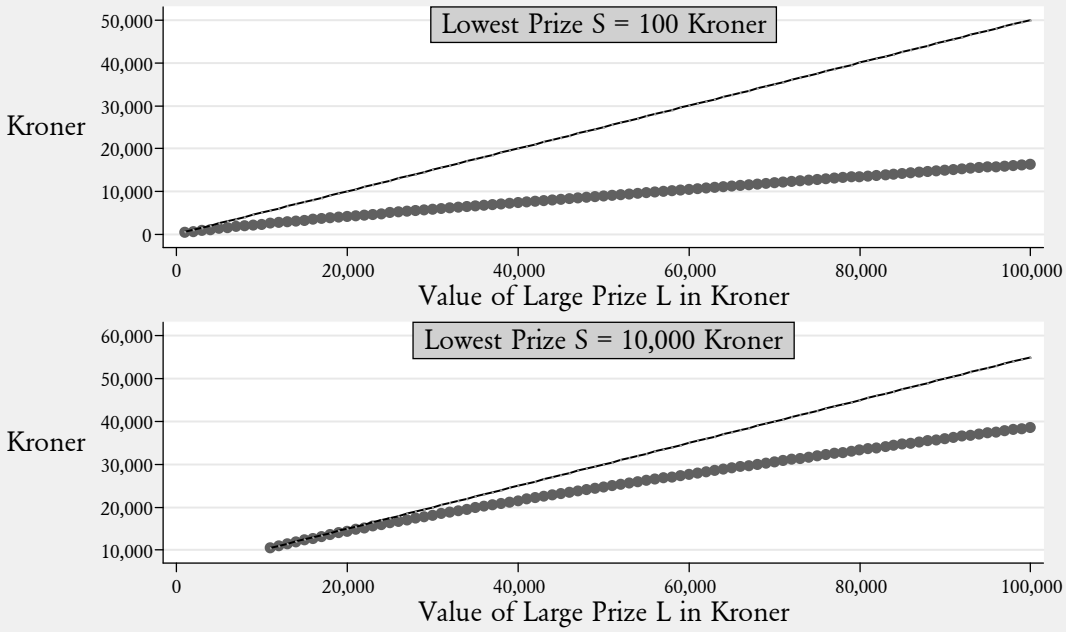


Figure 3: Arrow-Pratt Relative Risk Aversion for Estimated EUT-PAI Model

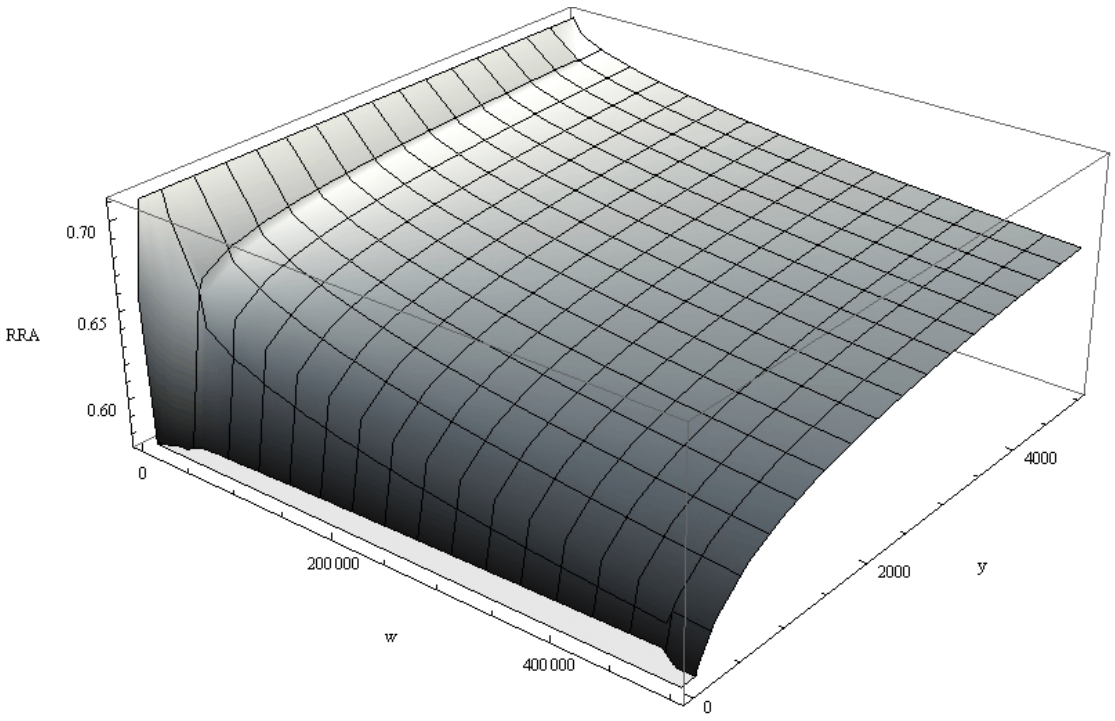


Table 5: Estimates Using RDU-PAI Model

Sample of 250 individuals making 7,524 choices of strict preference

Parameter	Point Estimate	Standard Error	*p*-value	95% Confidence Interval	
		A. Partial Asset Integration (LL = -3074.4)			
r	0.54	0.064	<0.001	0.42	0.67
γ	1.32	0.106	<0.001	1.11	1.53
σ	2.58	0.843	0.002	0.92	4.23
ω	0.033	0.05	0.506	-0.064	0.13
μ	0.13	0.007	<0.001	0.12	0.15
		B. Full Asset Integration (LL = -3157.5)			
r	0.17	0.084	0.039	0.009	0.34
γ	2.28	0.14	<0.001	1.99	2.55
μ	0.14	0.006	<0.001	0.13	0.15
		C. No Asset Integration (LL = -3080.1)			
r	0.5	0.056	<0.001	0.4	0.61
γ	1.33	0.109	<0.001	1.11	1.54
μ	0.13	0.007	<0.001	0.12	0.15

Figure 4: Probability Weighting and Decision Weights
With Partial Asset Integration

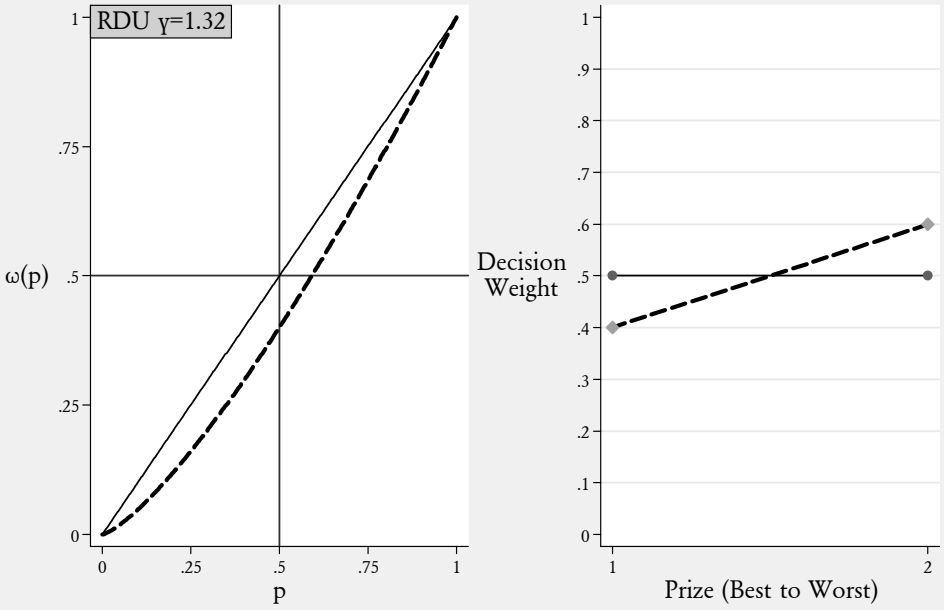


Figure 5: Probability Weighting and Decision Weights
With Full Asset Integration

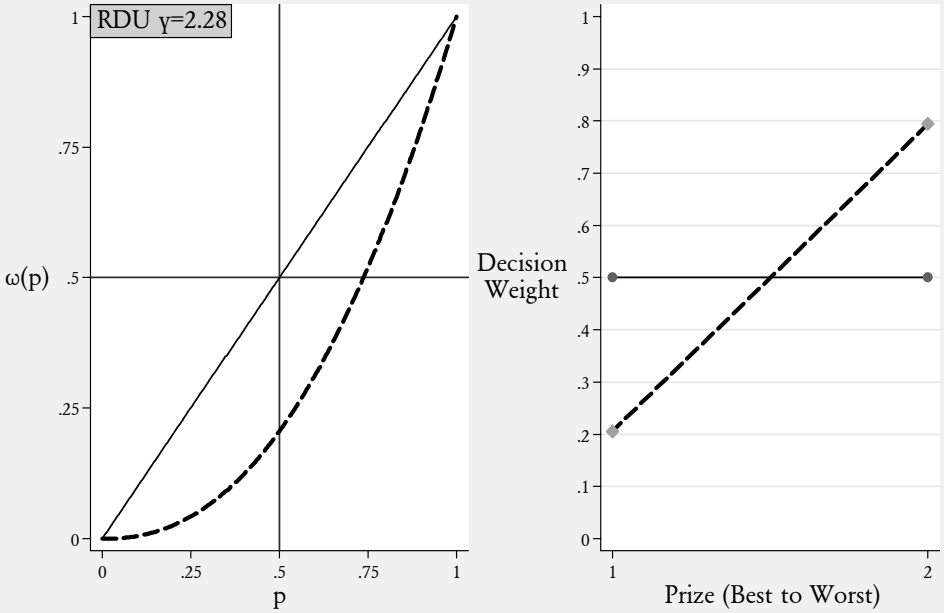


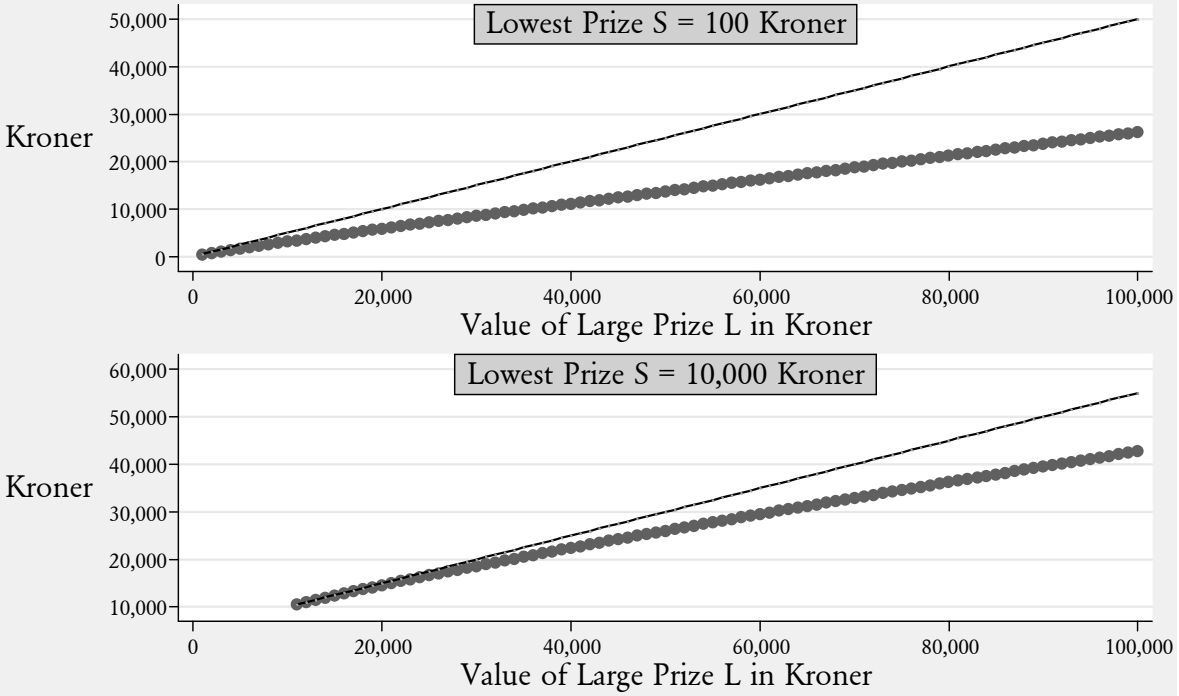
Table 6: Implied Certainty Equivalents Using RDU-PAI Model

Calculations with average wealth

Large Prize (DKK)	Probability of Large Prize	Small Prize (DKK)	Expected Value (DKK)	Certainty Equivalent (DKK)	Ratio
		A. Risky Lottery in Experiment			
200	0.5	100	$150.00	$137.00	0.91
500	0.5	100	$300.00	$228.00	0.76
1,000	0.5	100	$550.00	$362.00	0.66
2,000	0.5	100	$1,050.00	$603.00	0.57
5,000	0.5	100	$2,550.00	$1,250.00	0.49
5,000	0.01	100	$149.00	$103.00	0.69
5,000	0.1	100	$590.00	$176.00	0.3
5,000	0.3	100	$1,570.00	$545.00	0.35
5,000	0.7	100	$3,530.00	$2,370.00	0.67
5,000	0.9	100	$4,510.00	$3,983.00	0.88
		B. Risk Lottery in Wealth			
200	0.5	$100	$150	$140	0.93
1,000	0.5	$100	$550	$460	0.83
5,000	0.5	$100	$2,550	$2,054	0.8
100,000	0.5	$100	$50,050	$38,580	0.77
11,000	0.5	10,000	10,500	10,399	0.99
50,000	0.5	10,000	30,000	25,742	0.86
100,000	0.5	10,000	55,000	44,808	0.81
400,000	0.5	10,000	205,000	149,129	0.73
400,000	0.01	100	4,099	837	0.2
400,000	0.1	100	120,070	69,446	0.58
400,000	0.3	100	200,050	142,150	0.71
400,000	0.7	100	280,030	232,096	0.83
400,000	0.9	100	360,010	339,502	0.94

Figure 6: Implied Certainty Equivalent of Lotteries Using Estimates from RDU-PAI Model

Thin line is EV and thick line is CE



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