

**Strategic Risk Management Behavior:  
What Can Utility Functions Tell Us?**

**Joost M.E. Pennings**

**and**

**Philip Garcia\***

*Selected paper prepared for presentation at the American Agricultural Economics  
Annual Meeting, Denver, Colorado, August 1-4, 2004*

Copyright 2004 by J.M.E. Pennings and P. Garcia. All rights reserved. Readers may  
make verbatim copies of this document for non-commercial purposes by any means,  
provided that this copyright notice appears on all such copies.

# **Strategic Risk Management Behavior: What Can Utility Functions Tell Us?**

## **Abstract**

The validity of the utility concept, particularly in an expected utility framework, has been questioned because of its inability to predict revealed behavior. In this paper we focus on the global shape of the utility function instead of the local shape of the utility function. We examine the extent of heterogeneity in the global shape of the utility function of decision makers and test whether its shape predicts strategic risk management behavior. We assess the utility functions and relate them to strategic decisions for portfolio managers ( $N = 104$ ) and hog farmers ( $N = 239$ ). The research design allows us to examine the robustness of our results and the extent to which the results can be generalized. Furthermore, we assess the shape of the utility functions for these decision makers applying two different methods. This allows us to further test the robustness of our empirical results. If there exists a relationship between the shape of the utility function and strategic decisions, both methods should yield the same result. The empirical results indicate that the global shape of the utility function differs across decision makers (fully concave or convex versus S-shaped), and that the global shape predicts strategic decisions (e.g., asset allocation strategy in the case of portfolio managers; type of production process employed in the case of hog farmers). These findings support the notion that the often criticized concept of utility is a useful concept when studying actual behavior, and highlight the importance of considering decision-maker behavior over a wide outcome range when examining strategic behavior.

## Introduction

Utility is an important theoretical concept in economics, marketing, finance, and the management sciences and has been extensively used to derive optimal behavior of decision-makers or to describe actual behavior (Schoemaker). The validity of the utility concept, particularly in an expected utility framework, has been questioned because of its inability to predict revealed behavior. There is an extensive body of literature that discusses these anomalies (e.g., Rabin, 1998, 2000; Camerer).<sup>1</sup> A particular challenge with utility is how to quantify the concept to permit testing of its empirical merits. Utility is often measured using the certainty equivalence technique (or elicitation techniques derived from it) in empirical studies that deal with decision making under risk (Keeney and Raiffa; Farquhar). In the certainty equivalence technique the researcher asks the decision maker to compare a lottery  $(x_l, p; x_h)$  with a certain outcome, where  $(x_l, p; x_h)$  is the two-outcome lottery that assigns probability  $p$  to outcome  $x_l$  and probability  $1-p$  to outcome  $x_h$ , with  $x_l < x_h$ . The researcher then varies the certain outcome until the respondent reveals indifference between the certain outcome denoted by  $CE(p)$ . Substituting in the expected utility model with the von Neumann Morgenstern utility  $u$  one obtains:  $u(CE(p)) = pu(x_l) + (1 - p)u(x_h)$ . After obtaining a set of certainty equivalents corresponding to different utility levels a function is fit to arrive at the decision maker's utility function.

Studies that use the certainty equivalence technique or related utility elicitation procedures to obtain the decision maker's utility function  $u(x)$  use the curvature of the

---

<sup>1</sup> In this paper we do not review this literature but refer the reader to Kahneman, Slovic and Tversky, Camerer, McFadden, and Thaler.

utility function as measured by the Pratt-Arrow coefficient,  $-u''(x)/u'(x)$ , as a proxy for the decision-maker's risk attitude (e.g., Binswanger, 1981, 1980; Smidts). The failure to find a relationship between decision-makers' utility functions and actual behavior may be attributed to the fact that the curvature of the utility function is a local measure, often conceptualized as an unidimensional construct. For example, Pennings and Smidts (2000) estimate an exponential function to relate the certainty equivalents to the corresponding utility levels. Scaling the  $u(x)$  between 0-1 only one parameter is needed to estimate the curvature of the utility function. While this approach is attractive since only one parameter needs to be estimated and the interpretation of that parameter is straightforward (i.e., it represents a decision-maker's risk attitude), the procedure condenses the potential multidimensionality of a decision-makers utility function to a single dimension which can result in a significant loss of valuable information. Specifically, this approach does not explicitly take into account the entire outcome range of the relevant attribute  $x$  used to obtain the utility function (often money is used as relevant attribute).

In this paper, using the elicitation procedures developed by Pennings and Smidts (2000), we investigate how strategic decisions are related to the entire (global) shape of the utility function rather than to the curvature of the utility function measure of risk attitude (Pratt-Arrow).<sup>2</sup> Specifically, we first investigate the shape of the utility function across the total outcome domain  $x$  to determine whether its shape (i.e., fully concave or convex vs. S-shaped) differs across decision makers. We then examine whether the differences in the global shape of the utility function affect strategic behavior. Strategic

---

<sup>2</sup> Global shape is defined as the general shape of the utility function over the entire outcome domain.

decisions are those that determine the overall direction and organization of an enterprise and have far reaching effects on its structure (e.g., Quinn, Mintzberg and James). These decisions have an impact on the whole outcome domain of the firm. Since the global shape of the utility function takes that total outcome domain into account (i.e., the total range of attribute  $x$ ), we suspect its shape to be a predictor for strategic decisions.

Kahnenan and Tversky, Rabin (2000), Rabin and Thaler Pennings and Smidts (2003) who argued that a local measure of utility may not be of great interest when trying to understand decision-makers behavior over a wide outcome range seem to support this hypothesis.

To test our hypothesis we assessed the utility function of 104 portfolio managers in face-to-face computer guided interviews using the certainty equivalence method who were managing their firms' equity investments or who were managing their own portfolios. The certainty equivalents were obtained through choice-based matching (Keeney and Raiffa). Furthermore, accounting data were available from these managers regarding their strategic behavior (e.g., whether or not they invest in non-exchange traded assets). In addition, we elicited the utility function of 239 hog farmers using a similar research design and obtained accounting data regarding their strategic decisions (e.g., production system employed). This research design allows us to test whether the hypothesis of the relationships between strategic behavior and the shape of the utility function holds for different domains. The hog farming context has been used in Pennings and Smidts (2003) as well to investigate the relationship between farmers' utility functions and their organization behavior, allowing us to further examine the robustness of their results.

The contribution of the research is twofold. We show that the global shape of the utility function differs across decision makers (fully concave or convex versus S-shaped), and that the global shape predicts strategic decisions (e.g., asset allocation strategy in the case of portfolio managers; type of production process employed in the case of hog farmers). These findings support the notion that the often criticized concept of utility is a useful concept when studying actual behavior, and highlight the importance of considering decision-maker behavior over a wide outcome range when examining strategic behavior. It is important to note that the research does not *explain* strategic behavior, rather it shows that strategic behavior can be *predicted* by the global shape of the decision-maker's utility function. Further, the research does not answer the question what drives the global shape of the utility function. We elaborate on this issue in the discussion section.

In the following section we discuss conceptual issues regarding the global shape of the utility function, followed by our research design. Subsequently the utility elicitation procedure is described and empirical results are presented and discussed.

### **Global Shape of Utility Functions**

Utility has been a concept that has been used throughout the history of economics. In 1789 Bentham discussed the concept of utility as being a central concept in understanding human behavior. The utility concept has been used in various ways in the economics literature, and is used to represent preferences (e.g., von Neumann Morgenstern context) or to determine preferences (neoclassical context). Furthermore utility has often been discussed in terms of “cardinal” and “ordinal” utility (von Neumann

and Morgenstern; Baumol; Mosteller and Nogee; Friedman and Savage; Alchian; Ellsberg; Schoemaker; Fuhrken and Richter). In the neoclassical context, ordinal utility provides only a ranking of risky prospects while cardinal utility refers to a decision-maker's strength-of-preference function for consequences under certainty. In a measurement context cardinal and ordinal utility refers to the scale properties of the utility function (whether or not utility has interval properties) (Stevens). In this paper we view utility as ordinal in the neoclassical context and cardinal in the measurement context.

In the economics literature, concave utility functions have been associated with risk aversion and convex utility functions with risk-prone behavior. Pratt and Arrow proposed a local measure of risk aversion for  $U(x)$  as the negative ratio of the second to the first derivative, i.e.,  $-\frac{U''(x)}{U'(x)}$ . This measure is invariant under linear transformation and assumes constant value for linear and exponential functions. This measure has been used to explain and predict risk management decisions. The curvature of the decision-maker's utility function is a convenient measure for empirical researchers as it can be estimated in a single-parameter model (e.g., exponential functions are often used to estimate the curvature of utility function assuming CARA). Various authors have used the local shape of the utility function to predict and explain behavior. In this context the curvature of the utility function is equated with a decision-maker's risk attitude. Often the exponential utility function given by  $u(x) = -e^{-cx}$  is used to represent a decision-maker's utility function. Modeling the curvature (e.g.,  $c$ ) of the utility function implies that the local shape of the utility function (e.g. risk aversion) is constant over the total outcome

range  $x$ , and hence the curvature of the utility function does not take the total outcome range into account.

Tversky and Kahneman's prospect theory suggested that the global shape of the utility function, - its shape across the total outcome range - could be useful when trying to understand decision making under risk. In prospect theory, the shape of a decision-makers' utility function is assumed to differ between the domain of gains and the domain of losses. The proposed convex/concave utility function predicts risk-prone behavior in the domain of losses and risk-averse behavior in the domain of gains. Evidence for convex/concave utility functions across the total outcome domain has been found by, among others, Fishburn and Kochenberger, Hershey and Schoemaker, Budescu and Weiss, Kuhberger, Schulte-Mecklenbeck and Perner, and Pennings and Smidts (2003).

### **Research Design**

We assess the utility functions and relate them to strategic decisions for two different classes of real decision-makers. This research design allows us to examine the robustness of our results and the extent to which the results can be generalized. The first class of decision makers are portfolio managers who are responsible for managing the assets that companies hold to meet retirement obligations. The second class of decision makers are hog farmers. Furthermore, we assess the shape of the utility functions for these decision makers applying two different methods. This allows us to further test the robustness of our empirical results. If there exists a relationship between the shape of the utility function and strategic decisions, both methods should yield similar results. We show that the relationship between the shape of the utility function and strategic decisions do not



depend on the particular choice of the family of utility curves. We first describe the decision contexts of the two classes of decision makers (portfolio managers and hog farmers), then describe the utility elicitation process followed by the two methods used to assess the global shape of the decision-maker's utility function.

### *Decision Context*

To examine whether the global shape of the utility function is driving strategic decisions we need a context in which strategic decisions can be observed and in which the utility functions can be elicited from decision makers that make strategic decisions. To test whether the hypothesis on the relationships between strategic decisions and utility functions holds for different domains we test the hypothesis in two domains that meet the requirements outlined above. The domains are portfolio managers making decisions regarding their portfolios, and hog farmers making decisions regarding the production process they employ.

### *Portfolio managers' context*

Portfolio managers make important investment decisions on a regular basis, weighing risk and returns and making trade-offs between the two. Portfolio managers will at times evaluate the asset allocation classes in which they invest. One of the strategic decisions that portfolio managers have to make is whether to invest in assets that are not traded in a central exchange. These assets, often referred to as "bricks and mortar", are direct investments in commercial property or in private companies. These investments are not as liquid as stocks and bonds which can easily be sold and bought through exchanges.

Furthermore these assets have relatively high transaction costs (e.g., one has to manage the property etc.). The trading characteristics of bonds and stocks are very different from the non-exchange traded assets. While bonds and stocks can be easily sold and bought almost immediately and price quotations are almost always present, non-exchange traded assets can not be bought and sold immediately and price information may not always be available. Euronext, the result of a merger of the financial markets in Amsterdam, Brussels, London and Paris, provided us with the names of portfolio managers from large corporations who were managing their firms' assets to meet retirement obligations and provided the names and addresses of private portfolio managers who managing portfolio on behalf of others or managed their own accounts. Individuals were contacted by phone, informed about the study, and invited to participate. If they agreed, an appointment was made to conduct the experiments during a later visit. The response rate was high, 87% of those invited chose to participate, totaling 104 portfolio managers.

### *Hog farming context*

Hog farmers make an implicit or explicit decision regarding the production system that they employ, a strategic decision that is far-reaching and that impacts the fundamental structure of the farm. In hog farming, two production systems are distinguished: the 'open production system' (OPS) and the 'closed production system' (CPS). In the OPS, both piglets are bought; piglets are then feed for three or four months until they are ready for slaughter. In the CPS the hog farmer breeds rather than buys the piglets, which requires a very different production system as the farmer has to take care of the breeding stock, the birth process etc. The two production systems have also different

characteristics with respect to the net cash flow streams it generates over time. In the OPS the hog farmers are more often and more explicitly confronted with input costs, than the hog farmers who choose the CPS, in particular the expenses of buying piglets (the costliest input in the production process). As a consequence the net-cash flow pattern is different for the different production systems. A list of Dutch hog farmers was obtained from the Dutch Farmers Union, and farmers were asked to participate in an University-led research project on risk. A total of 239 farmers participated in the computer guided interviews.

#### *Elicitation of Utility Function*

We assessed the utility function of the portfolio managers and hog farmers by means of computer-guided interviews. The utility function was measured using the certainty equivalence method (Keeney and Raiffa; Smidts). The certainty equivalents were obtained through choice-based matching (Keeney and Raiffa; Fischer et al.). In designing the lottery task, we took into account the findings of research on the sources of bias in assessment procedures for utility functions (Krzysztofowicz and Duckstein; Hershey, Kunreuther and Schoemaker; Hershey and Schoemaker; Harrison; Tversky, Sattath and Slovic; Kagel and Roth; Holt and Laury). The main sources of bias arise when the assessment does not match the subjects' real decision situation. What is particular powerful about the research design is that we are dealing with decisions in a *relevant* context ensuring that the task reflects the subjects' daily decision making behavior (Smith). For the portfolio managers this meant that certainty equivalence technique was formulated in terms of relatively high/low returns with a range of -5% to +20%, with a

probability of 0.5 and a fixed return.<sup>3</sup> The assessment of the certainty equivalents was an iterative process. If the manager chose alternative A (the 50/50 high/low return), the computer would generate a randomly a higher fixed return (alternative B) than the previous, thus making alternative B more attractive or a lower fixed price making alternative A more attractive. If the manager chose alternative B, the computer would generate randomly a lower or higher fixed return (alternative B) the next time, thus making alternative A (alternative B) more attractive.<sup>4</sup> The next measurement would start after the respondent had indicated an indifference between alternative A or B.

The research design for hog farmers was similar to the portfolio managers' research design except that the main attribute in the certainty equivalence technique is the price per kilogram live hog weight. The outcome levels range from 1.06 Euro to 1.95 Euro per kilogram live weight, representing all price levels of slaughter hogs that have occurred in the last five years. The 50/50 dimension of the lottery reflects the environment in which portfolio managers and hog farmers are exposed to. Various researchers have shown the stochastic behavior of both commodity prices and stock prices (Schwartz; Hilliard and Reis).

The measurement procedure was computerized and took about 20 minutes.<sup>5</sup> Nine points of the decision maker's utility function were assessed, corresponding to utilities of 0.125, 0.250, 0.375, 0.500, 0.625, 0.750, 0.875 (plus two consistency measurements on

---

<sup>3</sup> The in-depth interviews revealed that these boundaries reflected the managers' minimum and maximum expected returns

<sup>4</sup> This randomization was introduced since Harrison identified that there is an incentive for individuals to keep choosing A in the case there is no randomization, because by doing so, respondents would ensure receiving a higher fixed price.

<sup>5</sup> The experimental design, imbedded in the computer-guided interview, and the computer-guided interview program are available from the authors.

utilities 0.500 and 0.625). For details on a similar elicitation procedure, see Pennings and Smidts (2000).

### *Assessing the Shape of Decision-Makers' Global Utility Functions*

Based on previous studies we identify two broad classes of shapes; fully concave, fully convex or S-shaped (convex/concave). Fully concave or convex utility functions have been widely used in the economics literature. Evidence for fully concave or convex utility functions across the total outcome domain has been found by, among others, Binswanger (1982) and Pennings and Smidts (2000). An S-shaped utility function has been proposed in prospect theory (Kahneman and Tversky). In prospect theory, the shape of a decision-makers' utility function is assumed to differ between the domain of losses and the domain of gains. The proposed convex/concave utility function predicts risk-prone behavior in the loss domain and risk-averse behavior in the gain domain.

We assessed the shape of the utility function using two distinctive methods to test whether the assessment of a decision-maker's global shape of the utility function is robust.

In the first method, referred to as the EXP-IPT-method, we fit the observations for each decision maker (the nine assessed certainty equivalents) to both the negative exponential function (EXP) and to the log of the inverse power transformation function (IPT), and the latter being an S-shaped utility function.

In the second method to assess the shape of the utility function, the two-piece utility function method, we decompose the utility function into two exponential segments, one for consequences above the reference point (gain domain) and the other for

consequences below the reference point (loss domain). As a natural reference point we took the stated target return on their portfolio for the portfolio managers (the average target return in our sample was 9.5%). For the hog farmer context we used the average cost of production as reference point which was 1.31 Euro per kilogram live weight as identified by experts in that industry. By estimating the EXP-function for each segment, we obtain for each respondent two parameters:  $c_g$  for the gain domain and  $c_l$  for the loss domain (recall that  $c$  in the exponential function represents the Pratt-Arrow coefficient of absolute risk aversion). These parameters allow us to describe the decision-maker's shape of the utility function as a combination of  $c_g$  and  $c_l$ . We can classify decision makers based on four different shapes of the utility function:  $c_l > 0$  and  $c_g > 0$  implying a concave utility function for both gains and losses;  $c_l < 0$  and  $c_g < 0$  implying a fully convex utility function;  $c_l > 0$  and  $c_g < 0$  implying a reversed S-shaped utility function, and  $c_l < 0$  and  $c_g > 0$  implying an S-shaped function.

## **Results**

First we describe the results for the estimates of the global shape of the utility function for portfolio managers and hog farmers for both methods (EXP-IPT method and the two-piece utility function method), and discuss the classification of these decision makers by comparing the two methods. Subsequently, we examine the relationship between the global shape of the utility function and strategic decisions.

### *Heterogeneity in the Global Shape of the Utility Function*

We first determined which functional form best reflects each decision maker's utility function based on a pairwise comparison of the mean squared errors (MSE) and classify

the decision makers in the corresponding groups (fully convex/concave or S-shaped). One group consisted of portfolio managers whose utility function is best described by the exponential function (an EXP-group;  $n = 53$  (51%)), the other group consisted of portfolio managers whose function is best described by the S-shaped function (an IPT-group;  $n = 51$  (49%)). A comparison of the estimation results from the homogeneous case (i.e., estimation results of the EXP and IPT function for all decision makers) with those from the heterogeneous case (estimation results for the EXP-group and IPT-group) indicated that the average fit for *both* functions increases and that the parameter estimates change substantially when taking heterogeneity into account. In particular, the mean MSE of the EXP-function drops from 0.007 for the total group to 0.004 for the 51 EXP-subjects. For the IPT-group, the increase is 0.002. Similar results were found for the hog farmers. One group consisted of hog farmers whose utility function is best described by the exponential function (an EXP-group;  $n = 144$  (60%)), the other group consisted of hog farmers whose function is best described by the S-shaped function (an IPT-group;  $n = 95$  (40%)). Also here we find heterogeneity with respect to the shape of the utility function. The average fit for *both* the EXP and IPT functions have increased and that the parameter estimates have changed substantially by taking heterogeneity into account. These results show that decision makers differ regarding the global shape of their utility function. Next, we examine the global shape of the utility function using the two-piece utility function method, allowing us to examine whether the results of the EXP-IPT-method are robust.

The results for the two-piece utility function method for portfolio managers indicate that 47.1% ( $n = 49$ ) of the portfolio managers have utility functions that are

concave for both the loss and gain domain (i.e.,  $c_l > 0$  and  $c_g > 0$ ), and hence are said to be risk averse across the total outcome domain (e.g., Table 1). A smaller group of portfolio managers (5.7%;  $n = 6$ ) can be described as being risk prone across the entire outcome domain (i.e.,  $c_l < 0$  and  $c_g < 0$ ). Only a few portfolio managers (6.7%;  $n = 7$ ) show a reversed S-shaped utility function (i.e.,  $c_l > 0$  and  $c_g < 0$ ) and 40.4% ( $n = 42$ ) of the portfolio managers exhibit an S-shaped utility function. These results confirm our previous finding using the EXP-IPT method that portfolio managers differ regarding the global shape of their utility function. For hog farmers, we also find that, using the two-piece utility function method, they differ regarding the global shape of the utility function, supporting our earlier findings. Table 1 shows that the two-piece utility function method results indicate that 47.1% ( $n = 49$ ) of the hog farmers have utility functions that are concave for both the loss and gain domain (i.e.,  $c_l > 0$  and  $c_g > 0$ ), and hence are said to be risk averse across the total outcome domain. A smaller group of hog farmers (5.8%;  $n = 6$ ) can be described as being risk prone across the entire outcome domain (i.e.,  $c_l < 0$  and  $c_g < 0$ ). Only a few hog farmers (6.7%;  $n = 7$ ) show a reversed S-shaped utility function (i.e.,  $c_l > 0$  and  $c_g < 0$ ). About 40.4% ( $n = 42$ ) of the hog farmers exhibit an S-shaped utility function



### *Robustness of Classification*

To examine whether the EXP-IPT-method and the two-piece utility function method identify similar global shapes of the utility function for decision makers, we compare the two methods for the portfolio managers and hog farmers.

**Table 1 Correspondence in Classification of the EXP-IPT-method and the Two-Piece Utility Function Method for Portfolio Managers and Hog Farmers**

	The EXP-IPT-Method	
<i>Portfolio Managers</i>		
Two-piece Utility Function Method	<i>EXP-function</i>	<i>IPT-function</i>
<i>Concave</i> function ( $c_l > 0$ and $c_g > 0$ ) 47.1% ( $n = 49$ )	<b>91.8%</b> ( $n = 45$ )	8.2% ( $n = 4$ )
<i>Convex</i> function ( $c_l < 0$ and $c_g < 0$ ) 5.8% ( $n = 6$ )	<b>83.3%</b> ( $n = 5$ )	16.6% ( $n = 1$ )
<i>Reversed S-shaped</i> function ( $c_l > 0$ and $c_g < 0$ ) 6.7% ( $n = 7$ )	14.3% ( $n = 1$ )	<b>85.7%</b> ( $n = 6$ )
<i>S-shaped</i> function ( $c_l < 0$ and $c_g > 0$ ) 40.4% ( $n = 42$ )	4.8% ( $n = 2$ )	<b>95.2%</b> ( $n = 40$ )
<i>Total</i>	50.9% ( $n = 53$ )	49.1% ( $n = 51$ )
<i>Hog Farmers</i>		
<i>Concave</i> function ( $c_l > 0$ and $c_g > 0$ ) 40.2% ( $n = 96$ )	<b>93.7%</b> ( $n = 90$ )	6.25% ( $n = 6$ )
<i>Convex</i> function ( $c_l < 0$ and $c_g < 0$ ) 18.4% ( $n = 44$ )	<b>89.1%</b> ( $n = 40$ )	9.1% ( $n = 4$ )
<i>Reversed S-shaped</i> function ( $c_l > 0$ and $c_g < 0$ ) 4.2% ( $n = 10$ )	30.0% ( $n = 3$ )	<b>70.0%</b> ( $n = 7$ )
<i>S-shaped</i> function ( $c_l < 0$ and $c_g > 0$ ) 37.2% ( $n = 89$ )	12.4% ( $n = 11$ )	<b>87.6%</b> ( $n = 78$ )
<i>Total</i>	60.3% ( $n = 144$ )	39.7% ( $n = 95$ )

The results in Table 1 show that classifying respondents with regards to the shape of the utility function is not dependent on the method used, providing evidence that the identification of the global shape of the utility function is robust.

### *Shape of Utility Functions & Strategic Decisions*

After showing heterogeneity in the shape of the utility function of real business decision-makers, we investigate whether the shape of the utility function is reflected in decision-makers' strategic behavior using the results of the EXP-IPT method to identify the global shape of the decision-maker's utility function. We do not present the results based on the two-piece utility function method which are similar to those presented.

The upper part of Table 2 shows how the functional form of a portfolio manager's global utility function (EXP vs. IPT) is related to strategic behavior. Overall, 44.2% of the portfolio managers invested only in exchange traded assets while 55.8% invested also in assets not traded on an exchange. Of the portfolio managers with a concave or convex utility function (the EXP-group), 17.0% invested only in exchange traded assets and 83.0% invested all assets. In contrast, of the portfolio managers with an S-shaped utility function (the IPT-group), 72.5% invested in only exchange traded assets, while 27.5% invested in non-exchange traded assets as well. These results indicate that portfolio managers whose global shape of the utility function can best be described by a EXP-type utility function (fully concave or fully convex over the total outcome range) have both exchange and non-exchange tradable assets in their portfolio, while portfolio managers whose global shape of the utility function can best be described by a IPT-type utility function (S-shaped utility function) invested only in exchange traded assets.

**Table 2 Relationship Between Shape of the Utility Function (IPT vs. EXP) and Strategic Decisions for Portfolio Managers and Hog Farmers.\***

<i>Portfolio Managers</i>			
	Invested only in exchange traded assets	Invested in all asset classes	Total
Total	44.2%	55.8%	100% ( <i>n</i> = 104)
EXP-group	17.0%	83.0%	100% ( <i>n</i> = 53)
IPT-group	72.5%	27.5%	100% ( <i>n</i> = 51)
<i>Hog Farmers</i>			
	CPS	OPS	Total
Total	54.4%	45.6%	100% ( <i>n</i> = 239)
EXP-group	77.8%	22.2%	100% ( <i>n</i> = 144)
IPT-group	18.9%	81.1%	100% ( <i>n</i> = 95)

\*Where the EXP-group consists of respondents for whom the shape of their utility function is described best by the exponential function (fully concave or fully convex), the IPT-group consists of respondents for whom the shape of their utility function is described best by the log of the inverse power transformation function (S-shape; see Appendix for function specifications). OPS denotes the open production system, CPS denotes the closed production system.

The lower part of Table 2 shows the relationship between the shape of the utility function and strategic behavior for hog farmers. Overall, 54.4% of the farmers employed the CPS production system and 45.6% employed the OPS system. Of the farmers with a concave or convex utility function (the EXP-group), 77.8% employed the CPS and 22.2% employed OPS. In contrast, of the farmers with an S-shaped utility function (the IPT-group), 18.9% employed CPS, while 81.1% used OPS.

The results of the portfolio manager domain and the hog farmer domain show that the global shape of the utility function is related to strategic behavior. To further gain insight in the predictive power of the global shape of the utility function we statistically test the relationship between the global shape of the utility function and strategic decisions by means of a logistic

regression analysis with the dichotomy of whether portfolio managers invest in all assets (exchange and non-exchange traded assets) or only in exchange traded assets, and whether hog farmers employ the CPS or OPS as the dependent variables and group-membership (EXP vs. IPT global utility function) as the independent variable. In the analysis for the portfolio managers, we controlled for the size of the portfolio managers' portfolio, age, education, and debt-to-asset ratio. In the analysis for the hog farmers, we controlled for, age, education, and debt-to-asset ratio.

Table 3 shows that the model for the portfolio managers significantly improves the fit, when compared to the null model, which includes only an intercept ( $p < 0.002$ ); Nagelkerke  $R^2 = 0.39$ , correctly classified choices 76.9%. The regression coefficient of the shape of the utility function was significant ( $p = 0.04$ ) in the logistic regression. The variables age ( $p = 0.15$ ), education ( $p = 0.15$ ), debt-to-asset ratio ( $p = 0.16$ ) and value of portfolio ( $p = 0.38$ ), were not significant. Table 3 shows also the results for the hog farmers. The model significantly improves the fit, when compared to the null model, which includes only an intercept ( $p < 0.00$ ; Nagelkerke  $R^2 = 0.42$ , correctly classified choices 79.1%).

**Table 3 Results of Logistic Regression in which the Shape of the Utility Function (IPT vs. EXP) Predicts Strategic Decisions**

	Portfolio managers		Hog farmers	
	Trading in all assets (=0) or trading in only exchange traded assets (= 1)		Production system employed by hog farmers: OPS (= 1) or CPS (= 0)	
	B	P	B	P
Shape of the utility function: (IPT = 1; EXP = 0)	-1.768*	0.04	2.83*	0.00
Age	0.07	0.15	-0.03	0.11
Education	-1.53	0.15	0.20	0.35
Debt-to-asset ratio	0.06	0.16	0.16	0.28
Average value of portfolio for which portfolio manager was responsible in 2000	0.53	0.38		
Nagelkerke $R^2$	0.39		0.42	
Correctly classified choices	76.9%		79.1%	

*Note.* The cutoff value in the misclassification test is 0.500. An asterisk indicates that each parameter significantly ( $p < 0.05$ ) improves the fit, when compared to the null model, which only includes an intercept. Nagelkerke's  $R^2$  is similar to the  $R^2$  in linear regression, and measures the proportion of variance of the dependent variable from its mean, which can be explained by the independent variables. The debt-to-asset ratio was measured on a 10-point scale with 1 = debt-to-asset ratio 1-9%, 2 = 10-19%, etc. The maximum level of education was measured on a 5-point scale ranging from high school to university degree, age is measured in years, the average value of the portfolio for which the portfolio manager was responsible was measured on a 8-point scale with 1 < 1 million, 2= 1-10 million, 3 = 10-50 million, 4 = 50-100 million, 5 = 100- 500 million, 6 =500 million – 1 billion, 7 = 1-5 billion, 8 = > 5 billion.

The regression coefficient of the shape of the utility function was clearly significant ( $p = 0.000$ ) in the logistic regression. The variables age ( $p = 0.11$ ), education ( $p = 0.35$ ), and debt-to-asset ratio ( $p = 0.28$ ) were not significant. These results further support the relationship between the global shape of the utility function and strategic behavior.

## Discussion

The results show that there is heterogeneity in the shape of utility functions of real decision makers and that this heterogeneity affects strategic decisions. The empirical results are robust with regards to the method used to determine the shape of the decision-maker's global shape of the utility function and the domain of the decision makers. These results indicate that the information that is embedded in the shape of the utility function is a predictor of actual strategic behavior. Furthermore, the results show that while the utility concept has been critiqued for not being useful when predicting actual behavior, it is a powerful concept when the decision-maker's global utility function is examined instead of the local utility function (e.g., curvature of the utility function).

There is an extensive body of literature that outlines the potential pitfalls of eliciting utility functions using certainty equivalent technique types of experiments (e.g., Harrison; Kagel and Roth; Holt and Laury). While the experimental design for this research was hypothetical in the sense that the choices that the decision makers made did not affect their actual wealth or well being, they were not hypothetical with regards to decisions that the respondents make. The certainty equivalent technique was designed so that the choices made during the experiments resembled their daily decisions. Hence, these decision makers were very experienced with regards to the consequences of these decisions. One of the portfolio managers even offered the comment "this isn't difficult; I make these decisions daily".

To test whether the elicitation technique suffered estimation biases as identified in the aforementioned references we conducted two additional analyses. First, we obtained two measurements at  $u(x) = 0.5$  and two at  $u(x) = 0.625$  during the utility elicitation process (for both portfolio managers and hog farmers), in order to investigate the internal

consistency of the assessments. When tested, the differences between the assessed certainty equivalents for the same utility levels were not significant ( $p > 0.99$  (pairwise test)) for both consistency measurements for the portfolio managers and hog farmers, showing that respondents assessed the certainty equivalents in an internally consistent manner. Second the parameter estimated of the S-shape utility function (IPT-group) allow us to calculate the average point of inflexion for the decision makers that best could be described by a S-shape utility function. The calculated point of inflexion of for hog farmers is 1.33 Euro per kilogram live weight hogs, which corresponds closely to the production costs of 1.31 Euro per kilogram estimated by experts from the industry at the time of the research. For the portfolio managers we used their target return to statistically compare the point of inflexion of portfolio manager  $i$  with the target return for portfolio manager  $i$ . When tested, the differences between the point of inflexion and the target return were not significant ( $p > 0.99$  (pairwise test)). These analyses clearly indicate that by using a realistic decision context using real business decision makers valid utility functions can be elicited (Smith).

In this paper we implicitly assumed that the global shape of the utility function drives strategic decisions. The rationale for this causality is that one could see the elicited utility function as a reflection of the decision-maker's behavior. However recent literature on constructed preferences argues that due to limited processing capacity, decision makers often do not have well-defined preferences, but these are constructed on the spot by an adaptive decision maker (e.g., Bettman, Frances and Payne; Butler). This literature argues that the decision context in which decision makers operate shapes their utility functions. Only longitudinal research can provide some empirical insight on this topic.

Such a research design would investigate whether decision makers change their strategic behavior and determine whether the shape of their utility function changes after a shape change in strategic behavior.

In this paper we did not explain strategic behavior. The question that needs to be addressed in future research is: what drives the shape of the utility function? While early work in economics focused on the drivers of utility (e.g., Lange; Armstrong) identifying the factors that determine the particular global shape of the utility function is unexplored territory.

## References

- Alchian, A.A. "The Meaning of Utility Measurement." *American Economic Review* 43(March 1953): 26-50.
- Armstrong, W.E. "The Determinateness of the Utility Function." *Economic Journal* 49(September 1939): 543-567.
- Arrow, K.J. *Essays in the Theory of Risk Bearing*. Chicago: Markham, 1971.
- Baumol, W.J. "The Von Neumann-Morgenstern Utility Index: An Ordinalist View." *Journal of Political Economy* 59(February 1951): 61-66.
- Bentham, J. *The Principles of Morals and Legislation*. Oxford: Clarendon Press, 1789.
- Bettman, J.R., L.M. Frances, and J.W. Payne. "Constructive Consumer Choice Processes." *Journal of Consumer Research* 25(1998): 187-217.
- Binswanger, H.P. "Attitudes toward Risk: Experimental Measurement in Rural India." *American Journal of Agricultural Economics* 62(August 1980): 395-407.



- Binswanger, H. P. (1981) "Attitudes toward Risk: Theoretical Implications of An Experiment in Rural India," *Economic Journal* 91(December 1981): 867-890.
- Binswanger, H.P. "Empirical Estimation and Use of Risk Preferences: Discussion." *American Journal of Agricultural Economics* 64(May 1982): 391-393.
- Budescu, D.V., and W. Weiss "Reflection of Transitive and Intransitive Preferences: A Test of Prospect Theory." *Organizational Behavior & Human Decision Processes* 39(1987): 184-202.
- Butler, D.J. "Do Non-Expected Utility Choice Patterns Spring from Hazy Preferences? An Experimental Study of Choice Errors." *Journal of Economic Behavior and Organization* 41(2000): 277-97.
- Camerer, C. "Individual Decision Making," in J.Kagel and A. Roth, eds., *Handbook of Experimental Economics*, Princeton: Princeton University Press, 1995.
- Ellsberg, D. "Classic and Current Notions of Measurable Utility." *Economic Journal* 64(September 1954): 528-556.
- Farquhar, P. H. "Utility Assessment Methods." *Management Science* 30(November 1984): 1283-1300,
- Fischer, G.W., Z. Carmon, D. Ariely, and G. Zauberman. "Goal-based Construction of Preferences: Task Goals and the Prominence Effect." *Management Science* 45(1999): 1057-1075.
- Fishburn, P.C. and G.A. Kochenberger. "Two-piece Von Neumann-Morgenstern Utility Functions." *Decision Sciences* 10(1979): 503-518.
- Friedman, M. and L. Savage. "The Expected Utility Hypothesis and the Measurement of Utility." *Journal of Political Economy* 60(December 1952): 463-474.

- Furken, G. and M. K. Richter 1991. "Additive Utility." *Economic Theory* 1(January 1991): 83-105.
- Harrison, G. "Risk Aversion and Preference Distortion in Deterministic Bargaining Experiments." *Economics Letters* 22 (1986): 191-196.
- Hershey, J.C., and P.J.H. Schoemaker. "Risk Taking and Problem Context in the Domain of Losses: An expected Utility Analysis." *Journal of Risk and Uncertainty* 47(1980): 111-132.
- Hershey, J. C., Kunreuther, H. C., P.J.H. Schoemaker. "Sources of Bias in Assessment Procedures for Utility Functions." *Management Science* 28(August 1982): 936-54.
- Hilliard, J.E., and J.A. Reis. "Jump Processes in Commodity Futures Prices and Options Pricing." *American Journal of Agricultural Economics* 81(May 1999): 273-286.
- Holt, C. A., and S.K. Laury. "Risk Aversion and Incentive Effects." *American Economic Review* 92(December 2002): 1644-1655.
- Kahneman, D. and A. Tversky. "Prospect Theory: An Analysis of Decision Under Risk." *Econometrica* 47(1979): 363-291.
- Kagel, John. H. and Roth, Alvin E. (eds.). *The Handbook of Experimental Economics* Princeton: Princeton University press, 1995.
- Keeney, R.L. and H. Raiffa. *Decisions with Multiple Objectives: Preferences and Value Tradeoffs*. Wiley, New York, 1979.
- Kuhberger, A., M. Schulte-Mecklenbeck, and J. Perner. "The Effects of Framing, Reflection, Probability, and Payoff on Risk Preference in Choice Tasks." *Organizational Behavior & Human Decision Processes* 78(1999): 204-231.

- Krzysztofowicz, R. and L. Duckstein. "Assessment Errors in Multiattribute Utility Functions." *Organizational Behavior and Human Performance* 26(1980): 326-348.
- Lange, O. "The Determinateness of the Utility Function." *Review of Economic Studies* 1(1934): 218-25.
- McFadden, D. "Rationality for Economists." *Journal of Risk and Uncertainty* 19(1999): 73-105.
- Mosteller, F. and P. Noguee. "An Experimental Measurement of Utility." *Journal of Political Economy* 59(October 1951): 371-404.
- Pennings, J.M.E. and P. Garcia. "Measuring Producers' Risk Preferences: A Global Risk Attitude Construct." *American Journal of Agricultural Economics* 83(2001): 993-1009.
- Pennings, J.M.E., and A. Smidts. "Assessing the Construct Validity of Risk Attitude." *Management Science* 46(October 2000):1337-1348.
- Pennings, J.M.E. and A. Smidts. "The Shape of Utility Functions & Organizational Behavior." *Management Science* 49(2003): 1251-1263.
- Pratt, J.W. "Risk Aversion in the Small and in the Large." *Econometrica* 32(January/April 1964):122-136.
- Quinn, J. B, H. Mintzberg, and R. M. James. *The Strategy Process*. Prentice Hall, Englewood Cliffs, New Jersey, 1988.
- Rabin M. "Psychology and Economics." *Journal of Economic Literature* 36(1998): 11-46.

- Rabin, M. "Risk Aversion and Expected-Utility Theory: A Calibration Theorem."  
*Econometrica* 68(2000): 1281-1292.
- Rabin, M., and R.H. Thaler. "Anomalies: Risk aversion." *Journal of Economic Perspectives* 15(2001): 219-232.
- Robison, L. J. "An Appraisal of Expected Utility Hypothesis Tests Constructed from Responses to Hypothetical Questions and Experimental Choices." *American Journal of Agricultural Economics* 64(May 1982): 366-375.
- Schoemaker, P.J.H. "The Expected Utility Model: Its Variants, Purposes, Evidence and Limitations." *Journal of Economic Literature* 20(1982): 529-563.
- Schwartz, E.S. "The Stochastic Behavior of Commodity Prices: Implications for Valuation and Hedging." *Journal of Finance* 52(July 1997): 923-73.
- Smidts, A. "The Relationship Between Risk Attitude and Strength of Preference: A Test of Intrinsic Risk Attitude." *Management Science* 43(March 1997):357-370.
- Smith, V. L. "Rational Choice: The Contrast between Economics and Psychology." *Journal of Political Economy* 99(August 1991): 877-97.
- Stevens, S.S. "On the theory of Scales of Measurement." *Science* 103(1946): 677-80.
- Thaler, Richard H. "From Homo Economicus to Homo Sapiens." *Journal of Economic Perspectives* 14(2000): 133-141.
- Tversky, A., S. Sattath, and P. Slovic. "Contingent Weighting in Judgment and Choice." *Psychological Review* 95(July 1988): 371-84.
- Von Neumann, J. and O. Morgenstern. *Theory of Games and Economic Behavior*.  
Princeton, Princeton University Press, 1944.