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| Erasmus university rotterdam |
| Choice Anomalies & Learning Effects |
| A Literature Study |
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| In economics, models are used in order to simplify and model reality. Rationality is a notion that mostly lies at the heart of these models. Economics agents are assumed to behave rational and make rational decisions. In order to act in a rational manner, one has to behave according to a set of rules, called axioms. In real life however, economic agents show systematic violation of these axioms, called choice anomalies. The rationality notion is often defended by the fact that there are significant learning effects. This thesis will study the effect learning has on choice anomalies. Although not entirely eliminated, it appears that there are positive effects. |

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# Preface

This Thesis is written for the completion of my Bachelor Economics and Business Economics at the Erasmus School of Economics faculty in the Erasmus University of Rotterdam

First, I would like to thank my supervisor Yu Gao for her help and feedback throughout this whole process.

Finally, I would like to thank my family and friends for supporting throughout my whole education.

Enjoy Reading.

Karin Leunis  
Rotterdam, May 2013

# Introduction

In standard economics and behavioral economics models are used in order to simplify and model reality. In order to use these models one has to make some simplifying assumptions. One of these assumptions is that people, henceforth referred to as economic agents, are assumed to be rational and thus make rational choices. The reality learns, however, that economic agents do not always make rational decisions. The systematic occurrence of this behavior is referred to as choice anomalies. The problem of irrational choice can be approached in two ways, the former by looking at the properties of the economics agents, and the latter by looking at the environment in which the choice will be made (Simon, 1955).

The proponents of the rationality assumption defend the failure of economic agents to make rational choices by the argument that there are significant learning effects for economic agents on the long term or repeated term (Kahneman & Tversky, 1986). This thesis will focus on the effect of learning tools on violations of the rationality, i.e. choice anomalies. The following research question will be answered by means of a literature study:

*“What are the effects of learning tools, such as advice, feedback, and the effect of the market, on choice anomalies? ”*

The first section covers the rationality assumption, its theories and its application in presence of uncertainty. The second section will cover the choice anomalies. Finally, the third section will cover the effects of learning tools, such as feedback, advice, and the effect of the market, on choice anomalies. We will finish with a conclusion.

# Rationality

## Introduction

The rationality assumption lies at the heart of most models in economics. Economics agents are assumed to behave rational and make rational decisions (Frank, 2008).

## The Expected Utility Theory

The notion of rationality has changed during the years going from an Expected Value Theory to an Expected Utility theory. Further developments were made and new theories were developed but these are beyond the scope of this text. According to the Expected Value Theory an economic agent chooses the option that maximizes his expected value (Edwards, 1954). In Bernoulli (1738), Daniel Bernoulli came up with the St. Petersburg Paradox as a problem of the Expected Value Theory. In the St. Petersburg Paradox the expected value of the game is infinite, but still economic agents don’t value the game as one with an infinite expected value. To account for this violation of the Expected Value Theory, Daniel Bernoulli proposed the Expected Utility Theory where an economic agent maximizes its expected utility instead of its expected value. Von Neumann and Morgenstern (1947) elaborated the Expected Utility Theory by developing a certain set of rules, called axioms, regarding an economic man’s preferences. If an economic man’s preferences are conform to these axioms, the economic man maximizes his expected utility (Von Neumann & Morgenstern, 1947).

Von Neumann’s and Morgenstern’s theory assume that there is an objective probability distribution available so an agent can make a decision while taking his/her risk profile into account. However, in presence of uncertainty such an objective distribution is not available. The economic agent can then use his expectations and beliefs to form a subjective probability distribution; this probability distribution is updated according to Bayes’ Theorem[[1]](#footnote-1). Savage (1954) incorporated this notion into Von Neumann’s and Morgenstern’s axioms. This brings us to our next topic.

## Axioms

Savage (1954) developed a set of rules an economic agent must follow in order to act rational in presence of uncertainty. These rules are called axioms. Savage proposed seven axioms of which the following four is the core set: cancellation, transitivity, dominance and invariance (Newell, Lagnado, & Shanks, 2007).

**Axiom 1: Cancellation.**

This axiom states that “any state of the world that yields the same outcome as the other states of the world, regardless of one’s choice, can be eliminated” (Kahneman & Tversky, 1986). For example, if bundle A is better than bundle B in any state of the world, then bundle B should be eliminated and one should prefer bundle A. The cancellation axiom is also known as the sure-thing principle.

**Axiom 2: Transitivity**

This axiom states that if bundle A is preferred over bundle B and bundle B is preferred over bundle C, then one must prefer bundle A over bundle C.

**Axiom 3: Dominance**

This axiom states that if bundle A is better than bundle B in one state/situation and it is at least as good as B in other states/situations, then bundle A should be chosen over bundle B. This axiom is also known as *monotonicity.*

**Axiom 4: Invariance**

This axiom states that different presentations of the same problems must lead to the same choice. Someone’s preference/choice should not depend on how the bundles are presented.

In this thesis we will continue with the following definition of rationality: behavior/preferences that follow the four axioms from Savage.

## Criticism

In the last decades a lot of criticism arose regarding the Expected Utility Theory. Daniel Ellsberg reported human behavior that violated Savage’s axioms (Ellsberg, 1961). Mark J. Machina and many others thought of Savage’s Axioms as too rigid rules (Kiefer & Nyarko, 1995). Machina and Schmeidler (1992) relaxed Savage’s axioms framework in order to include probabilistic sophistication[[2]](#footnote-2), making it a more realistic model.

These objections and evidence against the Expected Utility Theory had a big impact on continued research on the subject. Herbert A. Simon (1955) proposed the concept of *Bounded Rationality*. He states that economic agents are limited in his/her capacities in processing and gathering information, thus making it impossible to fully apply rational choice. In Bounded Rationality utility maximization has been replaced with utility satisficing (Simon, 1955). Some researchers tried including other areas in their research (Edwards, 1968). Other researchers proposed alternative or modified theories of decision making behavior, such as Kahneman’s and Tversky’s Prospect Theory (Kahneman & Tversky, 1979a).

Reality learns that human behavior is not always conform to these axioms. In fact, economic agents quite often make decisions that contradict these axioms of rationality. We will continue in more depth in the next section.

# Violations of Rationality

## Introduction

Standard economics view economic agents as rational individuals who maximize their own utility. Recall that rationality is behavior in accordance with Savage’s axioms. In real life however, economic agents often make choices that contradict Savage’s axioms of rationality. In this section a few examples of these violations and their implications on the rationality assumption will be given.

## Violation of Axiom 1: Cancellation

The cancellation axiom or the sure-thing principle is the most fundamental axiom in Savage (1954). Violations of the cancellation axiom were found by Allais (1953) and Ellsberg (1961).

Maurice Allais let people choose between these two options in each problem (Allais, 1953):

*Problem 1*

and

*Problem 2*

and

Choosing option [A] in problem 1 and option [B] in problem 2 is a violation of the cancellation axiom of Savage. The following derivation will make the violation clear:

Choosing [A] in problem 1 means:

( 1 )

Rearranging equation (1) gives:

( 2 )

Choosing [B] in problem 2 means:

( 3 )

As one can see equation (2) and (3) contradict each other.

Still, most people chose option [A] in problem 1 and option [B] in problem 2. Re-representing problem 1 as is done in the previous derivation gives the following problem:

*Problem 1 revised*

and

The inconsistency becomes very clear now. The economic agent fails to recognize the similarities in the two problems. Their preferences are not independent of common outcomes and thus they violate the cancellation axiom. Kahneman and Tversky presented the problem in different ways and found the same violation of the cancellation axiom (Kahneman & Tversky, 1979a) .

Daniel Ellsberg found another paradox that is not conform to the cancellation axiom. Ellsberg presented the following two problems (Ellsberg, 1961):

*Problem 1*

Imagine jar I with 50 red marbles and 50 black marbles which has the following payoffs:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Red | Black |  |
| Bet on Red | $100 | $0 |  |
| Bet on Black | $0 | $100 |  |

Now imagine that jar II has 100 red and black balls, in an unknown ratio, with the following payoffs.

*Problem 2*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Red | Black |  |
| Bet on Red | $100 | $0 |  |
| Bet on Black | $0 | $100 |  |

First the participants were asked on which color they would like to bet in case they would draw a marble from jar I/jar II. In both cases, the participants were indifferent between the colors, as expected. Second they were asked from which jar they would prefer to draw a marble if they get a $100 for drawing a red/black marble. People preferred drawing a marble from jar I when they will receive a $100 for drawing a red marble, but they also preferred jar I when they will receive a $100 for drawing a black marble. Here is where the violation comes into play, the following derivation will show why:

Preferring to draw a red marble from jar I means:

( 4 )

Also preferring to draw a black marble from jar I means:

**( 5 )**

Notice that: , so we can rewrite the second equation as follows:

( 6 )

Rewriting this will give us:

( 7 )

By comparing equation (4) and (7) the contradiction becomes clear.

This paradoxical behavior is also known as *Ambiguity aversion.* People are more willing to bet on outcomes with known probabilities, i.e. jar I, than on outcomes where the probabilities are unknown, i.e. jar II (Ellsberg, 1961).

## Violation of Axiom 2: Transitivity

The transitivity axiom seems quite obvious and almost impossible to violate. Still, violations of transitivity have been reported by researchers conducting experiments (Lichtenstein & Slovic, 1971). Lichtenstein and Slovic (1971) were the first to report the so called *preference reversals*, many subsequent papers confirmed Lichtenstein’s and Slovic’s result (e.g. Lindman (1971), Lichtenstein and Slovic (1973)).

Lichtenstein en Slovic presented their participants the following problem:

*Problem 1*

and

The participants were asked to choose one of the two options or to price the two options (i.e. how much money they would like to receive to give up the game). Most people preferred option A to B, but these participants that preferred option A gave option B a higher price than option A. This result is controversial and contradicts with the transitivity axiom; it appears that one’s preference depends on the method used to reveal one’s preference (Newell, Lagnado, & Shanks, 2007). The consequence of a violation of transitivity is that economic agents find themselves in a money-pump situation (Kahneman & Tversky, 1986). While in a money-pump situation, outsiders can make a profit out of them.

## Violation of Axiom 3: Dominance

The axiom of dominance is the cornerstone of the Expected Utility Theory (Johnson & Shin, 1991). Research has uncovered various violations of the dominance axiom (e.g. Kahneman & Tversky 1986, Arkes & Hammond 1986, Birnbaum 1992, and Birnbaum, Coffey, Mellers and Weiss 1992).

In a large set of different problems, a problem was presented to their participants in the following way (Kahneman & Tversky, 1986):

*Problem*There are five different colors of marbles in a jar with the following probabilities and payoffs. Which option do you choose to play?

[A]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 90% White | 6% Red | 1% Green | 1% Blue | 2% Yellow |
| $0 | Win $45 | Win $30 | Lose $15 | Lose $15 |

[B]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 90% White | 6% Red | 1% Green | 1% Blue | 2% Yellow |
| $0 | Win $45 | Win $45 | Lose $10 | Lose $15 |

All participants chose option [A] over option [B]. This is surprising, it is obvious that option [B] is better than option [A]. One must bear in mind however, that the participants in the previous experiment were asked to play and price a large amount of gambles. When asked to only price a small amount of gambles, less violations of the dominance axiom occurred (Mellers, Berretty, & Birnbaum, 1995).

## Violation of Axiom 4: Invariance

One’s choice should not depend on the way a problem is described/ presented. Although this may seem obvious, violations of the invariance axiom are often found in human decision making behavior. Framing effects play a huge role in these violations, as reported by Tversky and Kahneman (1981).

A classic example of a violation of the invariance axiom is the Asian disease experiment conducted by Tversky and Kahneman (1981). They presented the following two problems to the participants (Tversky & Kahneman, 1981):

*Problem 1*

Imagine that the USA is preparing for an outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs could to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the program are as follows:

and

*Problem 2*

Same background scenario as problem 1.

and

The two problems presented above are identical. Still, most people chose program [A] in problem 1 and program [B] in problem 2. Preferring program [A] over program [B] in problem 1 reflects the risk-aversion of economic agents when the problem is presented in terms of gains. Preferring program [B] over program [A] in problem 2 reflects the risk-seeking behavior of economic agents when a problem is presented in terms of losses. Not only is the framing of the two problems different, namely in terms of gains in problem 1 and in terms of losses in problem 2, but also the reference state of the problems are different. The outcome of problem 1 is viewed against a reference state of 600 people dying, the outcome of problem 2 is viewed against a reference state of no victims at all (Newell, Lagnado, & Shanks, 2007). Although the behavior of economic agents is not conform with the Expected Utility Theory in this situation, it is well predicted by the Prospect Theory (Tversky & Kahneman, 1981).

As this section shows, the behavior of economic agents is not always conform to the rules of rationality. Experiments conducted by researchers in the last few decades have demonstrated systematic violations of these axioms, challenging the notion of rationality that lies at the heart of most theories in economics. Proponents of the rationality assumption defend the failure of economic agents to make rational choices by the argument that there are significant learning effects. (Kahneman & Tversky, 1986). In the next section we will cover the methods of learning and their effect on the behavior of economic agents

# Learning effects and Violations of Rationality

## Introduction

As mentioned before, the decision-making behavior of the economic man does not always conform to the axioms. In the past few decades, systematic deviations from these axioms are uncovered by researchers. These systematic deviations, also known as choice anomalies, challenge the notion of rationality. Significant learning effects could be the solution to these choice anomalies. Learning effects has drawn the attention from many researchers in the past few decades. The question is if an economic agent can reach the optimal behavior by learning. Friedman (1998) stated that “Every choice anomaly can be greatly diminished or entirely eliminated in appropriately structured learning environments”, but Arrow (1958) stated that even after spending most of the time learning, an economic agent still will not be able to reach the optimal behavior. These two statements seem to contradict each other. In this section we will cover the effects of feedback, advice, and the market on learning by economic agents.

## Feedback

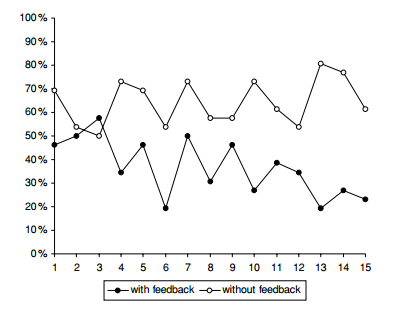
The rationale of feedback is that through trial-and-error, an economic agent can learn from their mistakes and improve their decision making ability throughout the time, i.e. learning. Feedback as an effective learning tool depends on one’s belief of the important determinants of a decision. In order for feedback to be an effective way of learning, the feedback giver must know what the determinants of a good/ optimal decision are, as highlighted by Klayman (1988).

Numerous empirical studies have been done by researchers to investigate the effect of feedback on learning (e.g. Steinmann (1976), Brehmer (1980)).

Brehmer (1980) found that with simple outcome feedback, i.e. only telling the agent if he did good or bad, learning effects were not present. The rationale behind this is simple, as Klayman (1988) made clear: one needs to find out the important determinants of a good optimal decision before being able to improve. When only being told if you did good or bad, you do not know why you did good or bad , and thus you are most likely not able learn and improve your performance. However, when economic agents are provided with more elaborate feedback and they are told about the importance of this information, they do improve their performance (Hammond, 1971). One have to bear in mind that most of these learning effects were found in experimental settings. In real life, one barely faces the same problem over and over again.

Van de Kuilen and Wakker (2006) studied the effect of feedback (not outcome feedback) as a learning tool on the Allais paradox. The following figure depicts their results:

Figure 1



The percentage on the y-axis reflects the percentage of expected utility violations, and the numbers on the x-axis reflects the number of rounds played. As one can see, with feedback, the percentage of expected utility violations decrease over de number of rounds, in contrast to economics agents that had not received feedback.

The effect of feedback as an effective learning tool disappears when economic agents lack the appreciation of feedback. Take for example university students, evidence has shown that students show little or no interest to the feedback on their work given by their professors (Duncan, 2007). In this case it is perhaps more convenient to give economic agents advice beforehand, also known as feed-forward. This brings us to the next topic.

## Advice

The idea of advice before making a decision is that people use this advice to update their beliefs and make predictions about the outcome of a decision. Advice can be given in the form of instructions, or any kind of information that facilitate the decision making process. An empirical study of Harries & Harvey (2000) has shown that economic agents that have been given advice before making a decision were better at finding out what the relevant determinants were and better at using the relevant information than economic agents that had just been given simple pieces of information, such as outcome feedback. This demonstrates the effectiveness of advice over feedback. A possible explanation for advice as a better learning tool than feedback is that information provided by an advice beforehand is less prone to errors and biases that occur and after making a decision (Newell, Lagnado, & Shanks, 2007). Errors and biases, which can accumulate in repeated games, can impede economic agent’s ability to learn in an optimal manner.

Daniel Friedman (1998) studied the effect of advice on the famous Monty Hall’s three doors game. In this game there are three doors, of which only one door has a prize. The participants are asked to pick one door. The game host opens one door with no prize, after he opened this empty door he asks the participants if they want to switch doors or if they want to stick with the same door. Bear in mind that switching doors is the rational choice[[3]](#footnote-4). However, in absence of advice, most people choose not to switch. Friedman (1998) found that, when providing the participants advice[[4]](#footnote-5) beforehand, the switch rate increased and thus people acted more rational. Although sticking with the same door does not violate one of Savage’s axioms in particular, it does violate Bayes’ Theorem which follows from Savage’s axioms (Kiefer & Nyarko, 1995).

As mentioned in the previous section, framing effects play a huge role in the violations of the dominance and invariance axiom. Framing effects caused researchers to reconsider the strength of the Expected Utility theory. On the other side there were also researchers who doubted the external validity by criticizing the experimental environment in which framing effects were found (e.g. James Druckman (2001)). The external validity refers to the degree of generalization of the results found in an experimental environment, in this case one could question if human behavior in an experimental setting also applies to all human behavior in real life settings. James Druckman (2001) criticized the fact that participants did not have access to advice or information, so he studied the effect of (credible) advice[[5]](#footnote-6) on framing effects. The advice was given in the form of a recommendation of the participant’s preferred political party. His results show that framing effects are heavily reduced and sometimes even eliminated when people are given advice.

So far we have seen positive effects of feedback and advice as learning tools. Researchers also proposed the market environment as an effective learning tool for economic agents. The effectiveness caused by, either gaining experience in the market environment or by the correcting tendency the market has on irrational behavior (Kahneman & Tversky, 1986). This brings us to our next topic.

## The Effect of the Market

The market environment can be seen as a repeated game where economic agents can gain experience, either through feedback, advice or some other learning activity. Hence, experienced market participants, i.e. active traders, should be less prone to violations of rationality, this is also known as the *refining hypothesis*. An alternative hypothesis is the *market discipline hypothesis*. The market discipline hypothesis states that economic agents can make costly errors, once they found an error to be costly they adjust their behavior in order to correct for them (Loomes, Starmer, & Sugden, 2003).

Empirical study has shown that violations of rationality are heavily reduced or even eliminated in a market environment. List (2002) studied experienced sport card traders and found that these active traders did not make the same preference reversal that the inexperienced traders did. Subsequent research confirmed this result in a real life economic environment (e.g. Cox and Grether (1996)). Cox and Grether (1996) observed preference reversals during a second price auction[[6]](#footnote-7) and found that preference reversals were heavily reduced after five rounds. These findings can be seen as a justification of the refining hypothesis.

Loomes et al. (2003) tested the empirical evidence of the both the refining hypothesis as the market discipline hypothesis. Their results showed a reduction of violations of rationality but it did not show which hypothesis caused the reduction.

It seems that experience has a positive effect on an economic agent’s performance. Kahneman & Tversky (1986), however, found no significant positive effects for experience in their experiment. In their experiment they presented a framing problem to their participants, but found no significant difference between the performance of regular participants and, for example, business students, mathematicians or other statistically sophisticated persons. They do not blame this on the concept of experience itself, but they do blame this on the lack of an effective learning environment. So, for experience to work, certain conditions have to be satisfied. The most important condition is the necessity of immediate feedback about the relevant determinants in the situation (Kahneman & Tversky, 1986). Here, we see again the importance of knowing the relevant and important determinants of an optimal decision in the particular situation mentioned earlier in this section.

To get back to the two contradicting statements in the beginning of this section by Friedman (1998), who stated that “every choice anomaly can be greatly diminished or entirely eliminated in appropriately structured learning environments”, and Arrow (1958), who stated that, even after spending a significant amount of time learning, an economic agent will not be able to reach optimal behavior. We can see that neither Friedman nor Arrow was completely wrong. Most of the empirical studies on learning effects found a heavy reduction of anomalies such as preference reversals, and improvements of Bayesian updating (Friedman (1998), Van de Kuilen & Wakker (2006)), however, Druckman (2001) even found elimination of an anomaly, namely framing effects that play a role in violations of the dominance and invariance axiom.

# Conclusion

Rationality is a highly debated topic in economics. In real life economic agents show systematic violation of rationality, called choice anomalies, causing people to doubt rationality.

The proponents of the rationality assumption often defend the assumption by the argument that economic agents have significant learning effects on the long or repeated term. In this thesis we studied these effects by looking at the effect of feedback, advice and the market as learning tools.

In theory, advice should be a better learning tool than feedback because it is less prone to errors and biases that can accumulate during the decision making process. In this thesis we have seen positive effects for both feedback and advice. Harries & Harvey (2000) found that performance was better in advice tasks than in feedback tasks. Still, it is not possible to confirm advice as a better learning tool than feedback with certainty.

The market also has a positive effect as learning tools, either by the experience gained in the market, or by the correcting behavior the market has. List (2003) found that experienced traders were less prone to preference reversals, Cox & Grether (1996) confirmed this result in a real market environment. Kahneman & Tversky (1986) on the other side, found no positive effect for experience performance.

It seems that learning has a significant positive effect on choice anomalies. Although they are not entirely eliminated, they are heavily reduced. One has to bear in mind however, that most results were found in an experimental setting, and thus can give doubt about the external validity of these findings.

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1. Bayes Theorem is a way of updating one’s beliefs by taking into account information revealed throughout the process. [↑](#footnote-ref-1)
2. “This means that there exists an unique subjective probability measure ‘x’ defined over the set of events, such that the individual ranks any pair of acts only on the basis of the lotteries they induce through ‘x’” (Grant, Özsoy, & Polak, 2007). [↑](#footnote-ref-2)
3. Opening a door with no price reveals new information about the door you have not chosen, this door now has a prize with a probability of 2/3 while the probability of the door you have chosen remains 1/3. Thus it is rational to switch doors. [↑](#footnote-ref-4)
4. This advice explained the rationale of switching doors. [↑](#footnote-ref-5)
5. Credible advice is advice on how people should behave (i.e. to act rational) [↑](#footnote-ref-6)
6. A second price auction is an auction where the highest bidder is able to buy the object being auctioned against the second highest bid. [↑](#footnote-ref-7)