Models in Microeconomic Theory

Expanded Second Edition

Martin J. Osborne Ariel Rubinstein





https://www.openbookpublishers.com

© 2020, 2023 (expanded second edition) Martin J. Osborne and Ariel Rubinstein



This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs license (CC BY-NC-ND 4.0). This license allows you to share, copy, distribute, and transmit the work providing you do not modify the work, you do not use the work for commercial purposes, you attribute the work to the authors, and you provide a link to the license. Attribution should not in any way suggest that the authors endorse you or your use of the work and should include the following information.

Martin J. Osborne and Ariel Rubinstein, *Models in Microeconomic Theory* (Expanded Second Edition), Cambridge, UK: Open Book Publishers, 2023, https://doi.org/10.11647/0BP.0361.

To access detailed and updated information on the license, please visit https://www.openbookpublishers.com/product/1171#copyright.

For further details on CC BY-NC-ND licenses, see https://creativecommons.org/ licenses/by-nc-nd/4.0/. All external links were active at the time of publication unless otherwise stated and have been archived via the Internet Archive Wayback Machine at https://archive.org/web.

Updated digital material and resources associated with this book are available at https: //www.openbookpublishers.com/product/1171#resources.

Every effort has been made to identify and contact copyright holders and any omission or error will be corrected if notification is made to the publisher.

ISBN Paperback: 978-1-80511-121-4 ISBN Hardback: 978-1-80511-122-1 ISBN Digital (PDF): 978-1-80511-123-8 DOI: 10.11647/OBP.0361

This book is available in two versions, one that uses feminine pronouns and one that uses masculine pronouns. This version uses feminine pronouns.

Version: 2023.5.30 (s)

Choice

2.1 Choice and rational choice

In the previous chapter we discuss an individual's preference relation, a formal concept that describes her mental attitude to all relevant alternatives. We now develop a formal tool to describe an individual's behavior. The two concepts, preferences and choice, are building blocks of the economic models we develop later.

Recall that the notion of a preference relation refers only to the individual's mental attitude, not to the choices she may make. In this chapter, we describe a concept of choice, independently of preferences. This description specifies her decision in any possible choice problem she may confront within the context we are modeling. Suppose, for example, that we want to model a worker who is applying for a job. Then a complete description of her behavior specifies not only which job she chooses if all jobs in the world are open to her, but also her choice from any subset of jobs that she might be offered.

Formally, let X be the set of all the alternatives an individual might face. A choice problem is a nonempty subset A of X, from which the individual chooses an alternative. A choice function describes the individual's choice for every possible choice problem.

Definition 2.1: Choice problem and choice function

Given a set *X*, a *choice problem for X* is a nonempty subset of *X* and a *choice function for X* associates with every choice problem $A \subseteq X$ a single member of *A* (the member chosen).

Usually in economics we connect the individual's behavior and her mental attitude by assuming that the individual is *rational* in the sense that

- she has a preference relation over *X*
- whenever she has to make a choice, she is aware of the set of possible alternatives
- she chooses an alternative that is best according to her preference relation over the set of possible alternatives.

Chapter of *Models in Microeconomic Theory* by Martin J. Osborne and Ariel Rubinstein. Version 2023.5.30 (s). (c) 2023 Martin J. Osborne and Ariel Rubinstein CC BY-NC-ND 4.0. https://doi.org/10.11647/OBP.0361.02

Note that this model of rationality does not make any assumptions about the content of the individual's preferences. Her preferences might be "irrational" in the everyday sense of the word and be inconsistent with what she, or we, would consider to be her well-being. For example, an individual who chooses an alternative that causes her the greatest pain (measured in some way) is rational in the sense we have defined.

If the preference relation of an individual is represented by the utility function u, then the individual acts as if she maximizes the function u under the constraint that $x \in A$. Formally we write her problem as

$$\max\{u(x): x \in A\}.$$

Note that if two individuals have two different strict preference relations and, given any set *A* choose alternatives in *A* that are best according to these preference relations, then their corresponding choice functions differ. That is, if for two alternatives *x* and *y* one individual prefers *x* to *y* and the other prefers *y* to *x*, then the choice function of the first individual assigns *x* to the problem $\{x, y\}$ and the choice function of the second individual assigns *y* to this set.

2.2 Rationalizing choice

Human beings usually do not consciously maximize a preference relation when they make decisions. The standard justification for modeling individuals as rational is that although individuals rarely explicitly choose the best alternatives according to their preference relations, their behavior can often be described *as if* they make choices in this way. Individuals do not have to be aware of their preference relations. The assumption that they maximize some preference relation is appropriate as long as we can describe them as if they behave in this way. Accordingly, we make the following definition.

Definition 2.2: Rationalizable choice function

A choice function is *rationalizable* if there is a preference relation such that for every choice problem the alternative specified by the choice function is the best alternative according to the preference relation.

Notice that this definition requires that the alternative chosen from any set is *the unique* best alternative. If we were to require only that it is a best alternative, then every choice function would be rationalizable by the preference relation in which all alternatives are indifferent. We return to the issue in Section 5.5.

Example 2.1

Let $X = \{a, b, c\}$. The choice function that assigns *a* to $\{a, b, c\}$, *a* to $\{a, b\}$, *a* to $\{a, c\}$, and *b* to $\{b, c\}$ is rationalized by the preference relation \succeq for which $a \succ b \succ c$. That is, we can describe the behavior of an individual with this choice function *as if* she always chooses the best available alternative according to \succeq .

On the other hand, any choice function that assigns *a* to $\{a, b\}$, *c* to $\{a, c\}$, and *b* to $\{b, c\}$ is not rationalizable. If this choice function could be rationalized by a preference relation \succeq , then $a \succ b$, $b \succ c$, and $c \succ a$, which contradicts transitivity.

Of the 24 possible choice functions for the case in which *X* contains three alternatives, only six are rationalizable.

We now give some examples of choice procedures and examine whether the resulting choice functions are rationalizable.

Example 2.2: The median

An individual has in mind an ordering of the alternatives in the set *X* from left to right. For example, *X* could be a set of political candidates and the ordering might reflect their position from left to right. From any set *A* of available alternatives, the individual chooses a median alternative. Precisely, if the number of available alternatives is odd, with $a_1 < a_2 < \cdots < a_{2k+1}$ for some integer *k*, the individual chooses the single median a_{k+1} , and if the number of alternatives is even, with $a_1 < a_2 < \cdots < a_{2k}$, then the individual chooses a_k , the leftmost of the two medians.

No preference relation rationalizes this choice function. Assume that *A* contains five alternatives, $a_1 < a_2 < a_3 < a_4 < a_5$. From this set, she chooses a_3 . If she has to choose from $\{a_3, a_4, a_5\}$, she chooses a_4 . If a preference relation \succeq rationalizes this choice function then $a_3 \succ a_4$ from her first choice and $a_4 \succ a_3$ from her second choice, a contradiction.

Note that the individual's behavior has a rationale of a different type: she always prefers the central option. But this rationale cannot be described in terms of choosing the best alternative according to a preference relation over the set of available alternatives. The behavior can be rationalized if we view the set of alternatives to be the positions $Y = \{\text{median, one left of median, one right of median, two left of median, two right of median}\}$. Then the first choice problem is Y and the second choice problem is $\{\text{one left of median, median, one right of median}\}$. The

preference relation \succeq given by

median \succ one left of median \succ one right of median $\succ \dots$

rationalizes the choice function.

Example 2.3: Steak and salmon

Luce and Raiffa (1957, 288) give an example of a person entering a restaurant in a strange city.

The waiter informs him that there is no menu, but that this evening he may have either broiled salmon at \$2.50 or steak at \$4.00. In a first-rate restaurant his choice would have been steak, but considering his unknown surroundings and the different prices he elects the salmon. Soon after the waiter returns from the kitchen, apologizes profusely, blaming the uncommunicative chef for omitting to tell him that fried snails and frog's legs are also on the bill of fare at \$4.50 each. It so happens that our hero detests them both and would always select salmon in preference to either, yet his response is "Splendid, I'll change my order to steak".

Consider a set *X* that consists of the four main courses, salmon, steak, snails, and frog's legs. No preference relation over *X* rationalizes the person's behavior, because such a preference relation would have to rank salmon above steak by his choice from $\{\text{salmon, steak}\}\$ and steak above salmon by his choice from *X*.

A reasonable explanation for the person's behavior is that although steak appears in both choice problems, he does not regard it to be the same dish. The availability of snails and frog's legs tells him that the steak is likely to be of high quality. Without this information, he views steak as low quality and chooses salmon.

No preference relation on *X* rationalizes the person's behavior, but a preference relation on {salmon, low quality steak, high quality steak, snails, frog's legs} does so:

high quality steak \succ salmon \succ low quality steak \succ snails \succ frog's legs.

An underlying assumption behind the concept of a choice function is that an alternative is the same in every choice set in which it appears. The choice function in the example cannot be rationalized because the example identifies two different options as the same alternative.

Example 2.4: Partygoer

Each of the people in the set $X = \{A, B_1, B_2\}$ organizes a party. A person might be invited to a subset of those parties and can attend only one party. Individuals B_1 and B_2 are both good friends of the partygoer but the relations between B_1 and B_2 are tense. The person's behavior is as follows. If she is invited by A and B_1 , she accepts B_1 's invitation. If she is invited by all three individuals, she accepts A's invitation. She does so because she is worried that accepting the invitation of B_1 or B_2 will be interpreted negatively by the other individual. Obviously such behavior is not rationalizable by a preference relation over X. As in the previous example, the meaning of choosing one alternative (B_1) is affected by the presence or absence of another alternative (B_2) .

2.3 Property α

We say that a choice function satisfies property α if whenever the choice from A is in a subset B then the alternative chosen from A is chosen also from B. We show that (*i*) any choice function that selects the best alternative according to a preference relation satisfies this property and (*ii*) any choice function that satisfies the property is rationalizable.

Definition 2.3: Property *a*

Given a set *X*, a choice function *c* for *X* satisfies property α if for any sets *A* and *B* with $B \subset A \subseteq X$ and $c(A) \in B$ we have c(B) = c(A).

Notice that property α is not satisfied by the choice functions in Examples 2.2, 2.3, and 2.4.

Proposition 2.1: Rationalizable choice function satisfies property α

Every rationalizable choice function satisfies property α .

Proof

Let *c* be a rationalizable choice function for *X* and let \succeq be a preference relation such that for every set $A \subseteq X$, c(A) is the best alternative according to \succeq in *A*. Assume that $B \subset A$ and $c(A) \in B$. Since $c(A) \succeq y$ for all $y \in A$ we have $c(A) \succeq y$ for all $y \in B$ and thus c(B) = c(A).

Proposition 2.2: Choice function satisfying property α is rationalizable

If *X* is a finite set then any choice function for *X* satisfying property α is rationalizable.

Proof

Let *c* be a choice function for *X* satisfying property *a*. Denote by *n* the number of elements in *X*. We construct a preference relation that rationalizes *c* as follows. Denote $c(X) = a_1$, $c(X \setminus \{a_1\}) = a_2$, $c(X \setminus \{a_1, a_2\}) = a_3$, and so on. That is, a_k is the choice from the set *X* after removing the elements a_1, \ldots, a_{k-1} .

Consider the preference relation \succeq defined by $a_1 \succ a_2 \succ \cdots \succ a_n$. Let *A* be a choice problem. The best alternative in *A* according to \succeq is the first member of *A* in the sequence a_1, a_2, \ldots, a_n , say a_m . By construction, $c(\{a_m, a_{m+1}, \ldots, a_n\}) = a_m$ and since $A \subseteq \{a_m, a_{m+1}, \ldots, a_n\}$ and $a_m \in A$, from property α we have $c(A) = a_m$.

2.4 Satisficing

Imagine an employer who must hire a worker. She interviews the candidates in alphabetical order until she reaches a candidate whom she considers to be good enough, and then stops. If no candidate is good enough, she chooses the last candidate to be interviewed.

Formally, denote the set of candidates by *X*. The employer has in mind a function $v : X \to \mathbb{R}$ that measures the candidates' qualities. She has in mind also a number v^* , an *aspiration level*. Let *O* be an ordering of the set *X* (for example, alphabetical order), which describes the sequence in which the employer interviews candidates. Given a set *A* of alternatives, the employer chooses the first alternative $a \in A$ in the ordering *O* for which $v(a) \ge v^*$ if such an alternative exists, and otherwise chooses the last element in *A* according to *O*.

Definition 2.4: Satisficing choice function

Let *X* be a finite set. Given a function $v : X \to \mathbb{R}$ (the *valuation function*), a number v^* (the *aspiration level*), and an ordering *O* of *X*, the *satisficing choice function c* is defined as follows. Let $A = \{a_1, ..., a_K\}$ where $a_1 O a_2 O \cdots O a_K$. Then

$$c(A) = \begin{cases} a_k & \text{if } v(a_k) \ge v^* \text{ and } v(a_l) < v^* \text{ for } l = 1, \dots, k-1 \\ a_K & \text{if } v(a_l) < v^* \text{ for } l = 1, \dots, K. \end{cases}$$

Every alternative x for which $v(x) \ge v^*$ is *satisfactory* and every other alternative is *unsatisfactory*.

Proposition 2.3: Satisficing choice function is rationalizable

A satisficing choice function is rationalizable.

This result can be proved by showing that any satisficing choice function satisfies property α (see Problem 3). Here we provide a direct proof.

Proof

Let *c* be the satisficing choice function for valuation function *v*, aspiration level v^* , and ordering *O*. We construct a preference relation \succeq that rationalizes *c*. At the top of the preference relation we put the satisfactory alternatives, $X^+ = \{x \in X : v(x) \ge v^*\}$, in the order given by *O*. Then we put all the unsatisfactory alternatives, $X^- = \{x \in X : v(x) < v^*\}$, in the order given by the *reverse* of *O*. (If, for example, $X = \{a, b, c, d\}$, *O* is alphabetical order, $v^* = 0$, and the valuation function is defined by v(a) = -1, v(b) = -2, v(c) = 1, and v(d) = 3, then the preference relation we construct is $c \succ d \succ b \succ a$.)

We now show that this preference relation rationalizes *c*. Let $A \subseteq X$. If *A* contains a member of X^+ then the best alternative in *A* according to \succeq is the first alternative, according to *O*, in $A \cap X^+$, which is c(A). If *A* does not contain a member of X^+ then $A \subseteq X^-$ and the best alternative in *A* according to \succeq is the last element in *A* according to *O*, which is c(A).

2.5 The money pump argument

The assumption that a choice function is rationalizable is sometimes defended on the ground that behavior that is inconsistent with rationality could produce choices that harm the individual.

Suppose that *X* consists of three alternatives, *a*, *b*, and *c*, interpreted as objects, and that an individual's choice function assigns *a* to $\{a, b\}$, *b* to $\{b, c\}$, and *c* to $\{a, c\}$. An implication of this choice function is that for any object *x*, if the individual holds *x* then there is an object *y* such that the individual is willing to exchange *x* for *y*; given that she prefers *y* to *x*, she is willing to pay some (possibly small) amount of money to make the exchange. Assume that for each such exchange, this amount of money is at least \$1. In this case, a manipulator could first give *a* to the individual, then offer to replace *a* with *c* in return for \$1, then

offer to replace c with b in return for another \$1, and then offer to replace b with a for yet another \$1. After these three exchanges, the individual holds a, as she did initially, and is \$3 poorer. The manipulator can repeat the exercise, taking as much money from the individual as she likes. Such a mechanism is known as a money pump.

In fact, for any choice function *c* that does not satisfy condition α , such manipulation is possible. Assume that there are sets *A* and *B* with $B \subset A \subseteq X$ and $c(A) \in B$ and $c(B) \neq c(A)$. The manipulation goes as follows.

Take c(A). (*i*) Are you willing to replace c(A) with any element in $B \setminus \{c(A)\}$ for some amount of money? The individual can now choose from the set *B* and will agree and choose c(B). (*ii*) Are you willing to replace c(B) with an alternative in $A \setminus \{c(B)\}$ for some amount of money? The individual can now choose from the entire set *A* and will agree and choose c(A). The manipulator can repeat the two steps as many times as she wishes.

The effectiveness of the manipulation depends on the inability of the manipulated individual to notice the exploitation. We leave it to you to judge whether the argument is a persuasive justification of the assumption that choice is rationalizable.

2.6 Evidence of choices inconsistent with rationality

Ample research demonstrates that human behavior is sometimes not rational in the sense we have defined. From the multitude of examples, we select three experiments that demonstrate this point; for each example, we identify features of behavior that are inconsistent with the assumption of rational behavior. The first experiment involves a situation in which some subjects' choices conflict with property α . The second and third experiments challenge the assumption that an individual chooses an alternative from a set, independently of the way the set is described. The experiments were first conducted many years ago (see the Notes at the end of the chapter). Here we report results of online experiments (using the website http://arielrubinstein.org/gt) in which the subjects were a large number of students around the world with similar academic backgrounds to those of the potential readers of this book.

2.6.1 Attention effect

Which of the following cameras do you choose?*Camera A* Average rating 9.1, 6 megapixels*Camera B* Average rating 8.3, 9 megapixels

Now make another choice.

Which of the following cameras do you choose?			
Camera A	Average rating 9.1, 6 megapixels		
Camera B	Average rating 8.3, 9 megapixels		
Camera C	Average rating 8.1, 7 megapixels		

Each question was answered by about 1,300 participants on the website http://arielrubinstein.org/gt. The results are given in the following tables.

Choice between A and B	Choice between <i>A</i> , <i>B</i> , and <i>C</i>			
	Camera A	30%		
Camera P = 5207	Camera B	68%		
Cumera B 52%	Camera C	2%		

Thus the appearance of *C* does not lead people to choose *C*, but rather causes a significant fraction of participants to choose *B*, which dominates *C*, even though in a choice between *A* and *B* they choose *A*. One explanation of this result is that the availability of *C* directs the participants' focus to *B*, the alternative that dominates it. An alternative explanation is that the dominance of *B* over *C* provides a reason to choose *B*, a reason that does not apply to *A*.

2.6.2 Framing effects

Sometimes individuals' choices depend on the way in which the alternatives are described.

You have to spin either roulette <i>A</i> or roulette <i>B</i> . The outcomes of spinning each roulette are given in the following table.						
		White	Red	Green	Yellow	
	roulette A	90%	6%	1%	3%	
		\$0	\$45	\$30	-\$15	
	roulette B	90%	7%	1%	2%	
		\$0	\$45	-\$10	-\$15	
Which roulette do you choose?						

Subjects' choices in this experiment are generally split more or less equally between the two roulettes. About 51% of around 4,000 participants at the website http://arielrubinstein.org/gt have chosen *A*.

A common explanation for the choice of *A* is that the problem is complicated and participants simplify it by "canceling" similar parameters. The outcomes of White in the two roulettes are identical and the outcomes of Red and Yellow are very similar; ignoring these colors leaves Green, which yields a much better outcome for roulette *A*.

Here is another choice problem.

You have to spin either roulette *C* or roulette *D*. The outcomes of spinning each roulette are given in the following table.

		White	Red	Black	Green	Yellow
	roulette C	90%	6%	1%	1%	2%
		\$0	\$45	\$30	-\$15	-\$15
	roulette D	90%	6%	1%	1%	2%
		\$0	\$45	\$45	-\$10	-\$15
Which roulette do you choose?						

It is clear that *D* dominates *C*, and indeed almost all participants (93%) at http://arielrubinstein.org/gt have chosen *D*.

Now notice that A and C differ only in their presentation (the color Yellow in A is split in C into two contingencies). The same is true of B and D (the color Red in B is split in D into two contingencies). The different presentations seem to cause at least half of the participants to apply different choice procedures: they reduce the complicated problem to a simpler one in the choice between A and B and apply a domination criterion in the choice between C and D.

2.6.3 Mental accounting

Imagine that you have bought a ticket for a show for \$40. When you reach the theatre you discover that you have lost the ticket. You can buy another ticket at the same price. Will you do so?

Now think about another situation.

Imagine that you intend to go to a show. When you take your wallet out of your pocket to pay for the \$40 ticket, you discover that you have lost \$40, but you still have enough cash to buy a ticket. Will you do so? In both of these situations, you face a choice between

- 1. having \$80 less than you did before departing home and seeing the performance
- 2. having \$40 less than you did before departing home and not seeing the performance.

Although in both situations you face these same options, more people choose to buy the ticket in the second situation than in the first situation. About 65% of the 1,200 participants at http://arielrubinstein.org/gt have stated that they would buy a new ticket in the first situation, in which they discover they have lost a ticket they purchased previously. Among a similar number of different participants, 79% have stated they would buy a ticket after discovering that they had lost \$40. The reason for the difference seems to be that in the first case people follow a mental accounting process that counts the price of a ticket as \$80, and they regard that price as too high. In the second case, some people appear to think about the loss of the \$40 as unrelated to the issue of ticket purchase and count the price of a ticket as only \$40.

Problems

- 1. *Five choice procedures*. Determine whether each of the following five choice functions over a set *X* is rationalizable. If the answer is positive, find a preference relation that rationalizes the choice function. Otherwise, prove that the choice function is not rationalizable.
 - *a*. The set *X* consists of candidates for a job. An individual has a complete ranking of the candidates. When she has to choose from a set *A*, she first orders the candidates in *A* alphabetically, and then examines the list from the beginning. She goes down the list as long as the new candidate is better than the previous one. If the *n*th candidate is the first who is better than the (n + 1)th candidate, she stops and chooses the *n*th candidate. If in her journey she never gets to a candidate who is inferior to the previous one, she chooses the last candidate.
 - b. The set X consists of n basketball teams, indexed 1 to n. The teams participate in a round robin tournament. That is, every team plays against every other team. An individual knows, for every pair of teams, which one wins. When she chooses a team from a set A, she chooses the one with the largest number of wins among the games between teams in A. If more than one team has the largest number of wins, she chooses the team with the lowest index among the tied teams.

- *c*. The set *X* consists of pictures. An individual has in mind *L* binary criteria, each of which takes the value 0 (the criterion is not met) or 1 (the criterion is met). Examples of such criteria are whether the painting is modern, whether the painter is famous, and whether the price is above \$1,000. The criteria are ordered: criterion₁, criterion₂, ..., criterion_{*L*}. When the individual chooses a picture from a subset of *X*, she rejects those that do not satisfy the first criterion. Then, from those that satisfy the first criterion, she rejects those that do not satisfy the second criterion. And so on, until only one picture remains. Assume that any two alternatives have a criterion by which they differ, so that the procedure always yields a unique choice.
- *d*. An individual has in mind two numerical functions, u and v, on the set X. For any set $A \subseteq X$, she first looks for the u-maximal alternative in A. If its u value is at least 10, she selects it. If not, she selects the v-maximal alternative in A.
- *e*. An individual has in mind a preference relation on the set *X*. Each alternative is either red or blue. Given a set $A \subseteq X$, she chooses the best alternative among those with the color that is more common in *A*. In the case of a tie, she chooses among the red alternatives.
- 2. Property of a choice function satisfying property α . An individual has a choice function that satisfies property α . Consider two sets, *A* and *B*, such that $c(A) \in B$ and $c(B) \in A$. Prove that c(A) = c(B).
- 3. *Alternative proof of Proposition 2.3.* Prove Proposition 2.3 by showing that any satisficing choice function satisfies property α .
- 4. Variant of satisficing. An individual follows a procedure that differs from the satisficing procedure only in that if she does not find any satisfactory alternative then she goes back and examines all the alternatives and chooses the one for which v(x) is highest. Show that the individual's choice function satisfies property α and construct a preference relation that rationalizes it.
- 5. *Path independence*. Consider the following property of a choice function, called *path independence*:

 $c(A \cup B) = c(\{c(A), c(B)\})$ whenever $A \cap B = \emptyset$.

That is, if the individual splits a choice set into two disjoint subsets, makes a choice from each subset, and then chooses between those two alternatives, she chooses the same alternative as she does when she chooses from the entire set.

- *a*. Let *c* be a choice function that assigns to each set the best alternative according to some preference relation. Show that *c* is path independent.
- b. Show that any choice function that is path independent is rationalizable (by showing it satisfies property α).
- 6. *Caring up to a limit*. An individual has in mind two numerical functions u and v defined on the set X. Given a choice problem A, she first looks for the u-maximal element x in A. If $v(x) \ge v^*$ she chooses x. Otherwise, she chooses the v-maximal element in A. (Notice that this choice function differs from the one in Problem 1d.)
 - *a*. Interpret the choice function in the case that *u* is a measure of the wellbeing of a friend and *v* is a measure of the wellbeing of the individual.
 - *b*. Show that for some *X*, *u*, and *v* the procedure is not rationalizable.
- 7. *Extension of Proposition 2.2.* Let *X* be an infinite set and *c* a choice function on *X*. Show, using the following two steps, that if *c* satisfies property α then it can be rationalized.
 - *a*. Define a binary relation \succeq by $x \succeq y$ if $c(\{x, y\}) = x$. Show that this relation is a preference relation.
 - *b*. Show that for every choice problem *A*, $c(A) \succeq a$ for every $a \in A$.
- 8. *Money pump.* Can a trader who thinks that 2 + 3 = 6 survive in our cruel world?

Notes

Property α was formulated by Chernoff (1954, Postulate 4, 429). The notion of satisficing is due to Simon (1956). The idea of a money pump appears to be due to Davidson et al. (1955, 145–146). Example 2.3 is taken from Luce and Raiffa (1957, 288). The experiment in Section 2.6.1 is based on the idea in Huber et al. (1982). The experiment in Section 2.6.2 was suggested by Tversky and Kahneman (1986, S263–S265). Section 2.6.3 is taken from Kahneman and Tversky (1984, 347–348). The exposition of the chapter draws on Rubinstein (2006a, Lecture 3).