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Boundedly Rational Consumers and Complex Pricing Schemes

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Natalia Shestakova

Dissertation

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[1]Luckily for the reader of this dissertation, those differential equations have never been solved.

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Introduction

That's been one of my mantras - focus and simplicity. Simple can be harder than complex: You have to work hard to get your thinking clean to make it simple. But it's worth it in the end because once you get there, you can move mountains.

Steve Jobs

For decades, economic research has been based on the assumption of the individual rationality of economic agents. Particularly, agents have been assumed to act according to their well-defined preferences when making all kinds of individual choices. The most convincing argument for relying on the rationality assumption is its analytical convenience. When behavior of each agent has a formal mathematical representation, we can study complex market interactions of agents, as well as the efficiency of possible market structures and policy interventions. The rationality assumption guarantees the existence of such formal mathematical representation.

My dissertation is an attempt to describe how boundedly rational consumers choose from a set of complex pricing schemes and to study how the presence of such consumers affects pricing strategies of a profit-maximizing monopolist. Bounded rationality is arguably a more realistic version of how humans make decisions. Agents still have well-defined preferences and are willing to maximize their well-being through the choices that they make. If they can find the best alternative, they always take it. The problem is in finding the best alternative when there are so many of them available on the market, and their values are not immediately observable.

Other attempts to understand how economic agents find the best alternatives have

been previously made by studying search behavior. Search models can be divided into two categories, both of them representing alternative-based search, i.e. when alternatives are evaluated one by one. The first one builds on the "satisficing" procedure proposed in Simon 1955. This procedure assumes that once an economic agent finds an alternative that sufficiently satisfies his desires, he takes it and stops searching. The term "aspiration level" is used to characterize these desires. The aspiration level is an exogenous variable in the original satisficing model, but it is endogenized in some of the later ones.

The other stream of search literature originates from the rational search-cost model proposed in Stigler 1961. Within this approach, the optimal stopping rule is endogenous and mathematically well defined. Particularly, economic agents are assumed to know the distribution of their choice alternatives so that they can evaluate expected benefits and costs of a further search. They continue searching as long as expected benefits are above expected costs and stop searching when expected benefits drop below expected costs.

Both representations of search behavior mentioned above are a step forward from the assumption that economic agents always choose the best available alternative, even when they need to find it first. These representations are capable of explaining certain patterns in observed market outcomes, e.g. why competing stores selling homogeneous goods can charge different prices. In some cases, one representation is more powerful than the other; in other cases, the reverse is true. There is still an important question that neither representation addresses: What determines the order in which choice alternatives are considered. In both types of models, there are no observables that can be used by economic agents to structure the search process, while in practice, economic agents often have some information on available alternatives before they start the search process.

I believe that by posing and partially answering questions related to ordering a search process based on the observable characteristics of available alternatives, my dissertation can move us towards a better understanding of important economic decisions made by individual agents. My partial answer to the question is that economic agents look for a match between their own characteristics and easily observable characteristics of available alternatives. This determines the order in which alternatives are evaluated.

This dissertation consists of three interconnected essays listed chronologically. The first two essays correspond to two lab experiments, and the third essay is a theoretical study that builds upon the experimental findings to analyze optimal pricing strategies of a profit-maximizing monopolist when consumers are boundedly rational. All three essays are united by the question how consumers' perception of their demand affects their choice

of complex pricing schemes.

In both experiments, subjects need to choose from a set of complex pricing schemes. Three main motives guide me to collect lab data for studying such choices instead of using field data that could range from saving plans to packages of different sizes in supermarkets. First, I want to be able to control the consumers' demand and their perception of it. Second, I want to see how consumers process the information on available pricing schemes. Third, I need enough variation in the parameters of pricing schemes to have different predictions from different decision rules. Below, I show which features of the experimental design bring me closer to satisfying these requirements.

Different approaches are used to control for the consumers' demand and their perception of it in the two experiments reported in this dissertation. In the experiment reported in Chapter 1, a consumption task is used for that, where subjects are offered a sequence of consumption units with specified benefits and costs. They are expected to consume those units whose benefits are higher than costs and to ignore those units whose benefits are lower than costs. After the consumption task is over, they are asked a sequence of questions that reveal their understanding of their demand. In the experiment reported in Chapter 2, subjects are given a specific demand range and are told that their payoff will be determined using several random independent realizations from this range.

To know how subjects process the information on prices, I use the Mouselab Web tool.[2] With this tool, all parameters of pricing schemes in both experiments are presented in a table format. Cells of the table are covered such that a subject has to click on the cell to see the corresponding parameter. He can see only one parameter at a given time. Every click is recorded by the program. This enables me to identify the sequence in which the information is acquired and to measure the time spent on observing each parameter.

Approaches used in the two experiments to enable the comparison of different decision rules also vary. In the experiment documented in Chapter 1, different sets of pricing schemes are offered to subjects from different treatments and, hence, predictions of the considered decision rules vary across treatments. Subjects need to choose a pricing scheme only once. In the experiment documented in Chapter 2, subjects are asked to make a choice 27-30 times, each time facing a different set of pricing schemes. Here predictions of the considered decision rules differ across tasks but are the same for all subjects.

The main experimental result presented in this dissertation comes from the second experiment. In that experiment, subjects are offered four three-part tariffs, where the three

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[2]The tool can be downloaded from its homepage: http://mouselabweb.org/.

parts are a fixed fee, a bundle of included units, and an extra-unit price. Their expected demand is always equal to the number of included units under one of the three-part tariffs. This tariff is, by the design, the best choice in only one-third of all experimental tasks, but it is chosen by subjects in 42.3% of the cases, hence revealing a systematic deviation from the expected-payoff-maximizing behavior.

I propose several explanations for this observation. The leading one is the "expected demand" heuristic. It assumes that when choosing from a set of three-part tariffs, instead of averaging consumption cost over a possible demand range, consumers take their expected demand and compute the corresponding cost under each tariff. Then, instead of taking the tariff with the lowest expected cost, they take the tariff with the lowest cost of the expected demand. When the cost function is convex at the possible demand range, and only then, the cost of the expected demand is lower than the expected cost. In the reported experiment, this is only the case for the tariff with the number of included units equal to the expected demand, and hence, the "expected demand" heuristic predicts a bias towards this tariff.

Another relevant explanation of the observed bias towards the tariff with the number of included units equal to the expected demand is a simple "match" heuristic. Use of the "match heuristics" assumes that subjects, instead of comparing how much they would pay under each tariff, simply choose the tariff whose immediately observable characteristic, which is the number of included units, "matches" their expected demand. This heuristic predicts that the tariff with the number of included units equal to the expected demand should be chosen regardless of other parameters of the offered tariffs, which make it different from the "expected demand" heuristic where other parameters matter. Notably, this naive decision rule is the best in explaining the choices of 25.5% of the subjects.

The analysis of process data allows me to make another important observation. Subjects are more likely to choose the alternative that they considered first. In addition, they are more likely to consider the "matched" three-part tariff first when the number of included units is reflected in the names of the offered tariffs and hence is immediately observable. This suggests that firms can nudge consumers with different demands towards the choice of different tariffs. This suggestion from the data analysis in Chapter 2 connects it with Chapter 3.

In Chapter 3, I study optimal pricing strategies of a profit-maximizing monopolist when consumers are boundedly rational and differ in their willingness to pay for the good. The consumers' bounded rationality is represented by their limited capacity to

compare available market offers. From all offers, they only compare offers from a specific sub-set. From the compared sub-set, they always choose the best one. This consumer behavior opens up a possibility for the monopolist to move from the second-best towards the first-best outcome in non-linear pricing. The monopolist can do so by offering the first-best tariffs together with tariffs that violate the participation constraints of all types of consumers but manage to distract the consumers' attention from better tariffs.

The necessary condition for the proposed pricing strategy to work is that consumers with differing willingness to pay also have different probabilities of comparing particular sub-sets of available tariffs. Particularly, consumers with a higher willingness to pay should be more likely to have a tariff that violates everyone's participation constraint in their consideration set. The possibility that this happens is supported by the experimental evidence documented in Chapter 2.

This dissertation broadly contributes to the literature on consumer and producer problems. In the experimental studies, I propose a design that enables researchers to gain a deeper understanding of consumer choices. The main result of the presented experimental studies is that a big portion of choice mistakes can be explained by simplified computation methods that economic agents use. This result is of a high importance, as such decision rules can be formally represented and implemented in the producer problem. In the theoretical study, I show that simple decision rules used by consumers may substantially affect the optimal pricing strategies of the profit-maximizing monopolist. The proposed decision rules are far less general than the expected utility maximization model. Nevertheless, they are applicable to a wide class of choice environments with complex choice alternatives.

0.1   Related Literature

The focus of this dissertation is on the choice of complex pricing schemes, three-part tariffs being the leading example. In the first two experimental studies, I explore how the consumers' choice of three-part tariffs can be manipulated. In the third theoretical paper, I find conditions that allow a monopolist to gain higher profits than the standard price discrimination predicts and relate these conditions to the findings of the experimental papers. Even though the choice of three-part tariffs is a very specific setting, I wish the dissertation to be viewed more broadly. Particularly, I want to stress that this choice should be treated as a search due to high cognitive costs that are involved. However,

in this case, the search is not alternative-based as consumers can easily observe the parameters of the offered alternatives and infer their values from those.

Literature from several areas needs to be discussed here. First, this will be the behavioral industrial organization literature that studies how profit-maximizing firms exploit deviations from rationality in consumer behavior. Then, it will be empirical literature that uses field data to report certain deviations in consumer behavior. I will then mention experimental studies that look at the errors in individual decision-making and a few attempts to model consumer behavior in a way that would explain the observed errors.

The existing behavioral IO literature has been reviewed in Ellison 2006 and, more recently, in Spiegler 2011.[3] This dissertation focuses on a monopolist's pricing strategies when consumers cannot process all available information. Previously, the consumers' inability to process information adequately has been studied mostly in the context of competitive markets. One example is Spiegler 2006, where consumers apply anecdote-based reasoning. Instead of treating their utility from dealing with a particular firm as random, which is the case, consumers acquire information on other consumers' experiences with each firm and believe that their own experience would be the same. Such behavior promotes the existence of markets where firms do not provide any additional value compared to the outside option.

Another relevant example comes from Gabaix and Laibson 2006. They study add-on pricing in the presence of myopic consumers, who choose among firms without taking into account that to enjoy consumption of the base good they would need to purchase add-ons in the future. This creates incentives for firms to hide the information on add-on prices, and even competitive forces cannot always solve this inefficiency. Hence, the presence of myopic consumers becomes an alternative explanation to information suppression, which can be also attributed to consumers' search costs as in Ellison 2005.

The two examples described above deliver a similar idea that when consumers are boundedly rational, competitive forces are incapable of solving the resulting market inefficiencies. In this dissertation, a different point is stressed. While the competitive market

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[3]Within the rational framework, these were search cost models (Stigler 1961 being one of the most famous), where the approach lately pursued in the behavioral IO literature was first introduced. The approach is to formalize the consumers' deviations from fully rational behavior, e.g. by using the idea of search costs and to study their implications for market outcomes. Mostly, these deviations were fit into the optimizing consumer behavior. The study of Smallwood and Conlisk 1979 is worth noting in this regard as their consumers rely on the market shares of different brands instead of updating beliefs about the quality of those brands. Ellison and Fudenberg 1995 develop a further market implication of this type of consumer behavior.

is originally socially optimal, the monopoly is associated with market inefficiencies. The presence of boundedly rational consumers in competitive markets produces inefficiencies, while their presence in a monopoly market creates incentives for the monopolist to capture more consumer surplus by making socially optimal offers.

A similar point has been previously raised in Della Vigna and Malmendier 2004, Eliaz and Spiegler 2006, Eliaz and Spiegler 2008, Esteban, Miyagawa, and Shum 2007, Esteban and Miyagawa 2011, Grubb 2009, and some others. These papers look at the monopolist's interactions with consumers whose behavior does not satisfy standard rationality assumptions and describe contract design that allows the monopolist to extract a higher share of consumer surplus. The specific deviations from rationality considered in these papers are the consumers' dynamic inconsistency and biased beliefs about future demand.[4]

As an example, in Grubb 2009, consumers are overconfident about the precision of their demand estimates. Instead of anticipating correctly that their demand will be in the range from a to b, consumers believe that it will always be in the middle. The firms' attempts to extract a higher share of consumer surplus in this case seem to be the most compelling explanation for the presence of three-part tariffs. When the demand realization is at the lower part of the range, consumers overpay due to the presence of a fixed fee. In the reverse case, they overpay due to steep over-usage charges. As these cases are not taken into account by consumers when they choose a three-part tariff, firms benefit by setting high penalties for deviating from the middle of the range.

As a contribution to behavioral IO literature, Chapter 3 of this dissertation focuses on the consumers' ability to process easily available information on prices assuming that they perfectly anticipate their future demand. This appears to be another chance for the monopolist to extract a higher share of the consumer surplus. He does so by offering pricing schemes that violate standard participation and incentive compatibility constraints. This pricing strategy has a positive effect on the monopolist's profit only when specific conditions derived in Chapter 3 are satisfied.

The discussed theoretical work has mostly been based on the observed patterns of prices charged in different types of markets. The common understanding of these patterns is that firms intend to confuse, or obfuscate, consumers and to exploit their not fully

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[4]Dynamically inconsistent preferences have been explored, among others, in Della Vigna and Malmendier 2004, where the authors explicitly rely on a quasi-hyperbolic discount function and compare the pricing of "leisure" and "investment" goods, and in Eliaz and Spiegler 2006, where the authors present price discrimination as a monopolist's screening of the consumers' degree of sophistication. Heidhues and Koszegi 2008 explore implications of the consumers' loss aversion.

rational preferences. This understanding is also supported by the empirical evidence of choice mistakes that consumers make. Such evidence comes from the consumers' choices of health club contracts (DellaVigna and Malmendier 2006), of local telephone tariffs (Miravete 2003), of mobile phone plans (Grubb 2009), of tariffs for internet access (Lambrecht, Seim, and Skiera 2007), of credit cards (Stango and Zinman 2009), and even of different-sized packages of light beer (Gu and Yang 2010).

As an example, the main finding in DellaVigna and Malmendier 2006, who use data on the individual choices of health club contracts and subsequent attendance, is that consumers who choose monthly or annual contracts pay, on average, $7 per visit more than they would have paid with a 10-visit pass. The leading explanation proposed by the authors is the consumers' overconfidence in their high attendance rate. The authors discuss other possible explanations, one of them being the consumers' willingness to commit to at least some exercising. Implicitly, this means that even though consumers anticipate a low attendance with a gym contract, they know that without any contract, their attendance will be even lower. Their net utility from buying a contract, equal to the utility from gym attendance, which is higher with the contract than without, minus its cost, might be still higher with the contract than without.

DellaVigna and Malmendier 2006 decline the latter as it seems to be inconsistent with another result showing that many consumers refrain from renewing their contracts after the contracts expire, in case they are not renewed automatically. There might be many motives not to renew the contract that do not contradict the consumers' sophistication about their attendance rate. One possibility might be that consumers achieved their goals even with those few exercises they did and do not have a desire to exercise any longer. My point here is that without knowing what consumers think their consumption would be with and without a particular contract, it is hard to discriminate among the potential explanations of consumers' choice mistakes. This provides the motivation to study consumer decisions using controlled economic experiments.

One of the first experimental studies that explore the consumers' choice of pricing schemes is a report on the impact of price frames (Huck and Wallace 2010) prepared for the Office of Fair Trading. The authors compare the subjects' search and purchase behavior under several price frames with a baseline treatment being flat per-unit prices. The price frames considered in the experiment are drip pricing (price increments, e.g. taxes, are dripped through the buying process); sales (with pre-sale prices given as a reference to subjects); complex pricing (e.g. "3 for the price of 2"); baiting (when only

a limited number of goods is available at the promoted price); and time limited offers. The authors find that all of these price frames distort consumer decisions in how much to search and how much to buy and result in overall welfare losses.

Being an excellent start in studying the consumers' choice of complex pricing schemes using laboratory experiments, Huck and Wallace 2010 do not yet address how the consumers' perception of their own demand affects the search process and outcome, particularly, whether consumers may use this perception and easily observable parameters of pricing schemes to structure the choice process. Other experimental studies, though, look at the so-called anchoring effect. The idea of an "anchoring and adjustment" heuristic originates from the work of Kahneman and Tversky in the 1970s. Tversky 1972 suggests that a decision maker first observes the parameters of the available alternatives, then eliminates some of the alternatives relying on easy-to-implement criteria and only then evaluates the remaining ones.[5] When the search is treated this way, the consumers' perception of their own demand can be a part of easy-to-implement criteria that they use to sort away certain alternatives.

A typical approach used to explore anchoring effects in economic experiments is to ask subjects for an irrelevant number, e.g. the last two digits of their ID, and then to elicit their willingness to pay for specified and displayed goods. Simonson and Drolet 2004 report that subjects with the IDs whose last two digits make for a larger number are willing to pay a higher price for a bottle of wine.

Most existing experimental studies of individual decision making (as opposed to games and markets) use the choice from a set of gambles as an environment. The experimental evidence collected in such an environment gave rise to a number of alternative theories of decision making. With a few exceptions (see Hey, Lotito, and Maffioletti 2008), these theories are generalizations of the expected utility theory. Namely, they explain certain deviations from supposedly optimal behavior by modifying the decision makers' objective function.[6] The major objection to extending expected utility theory (see Gigerenzer, Todd, and the ABC Research Group 1999) is that adding more parameters into the model improves its fitting ability (so that the collected data will be explained) but not its predictive power (so that it is not guaranteed that new data will be predicted correctly).

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[5]More generally, Tversky and Kahneman 1974 propose that when choosing from a set of complex alternatives, decision makers rely on heuristics instead of computing and comparing the values of each alternative.

[6]For a comprehensive summary of emergent theories and an investigation of their potential superiority over the expected utility theory, see Hey and Orme 1994. The authors show that such superiority is, in fact, questionable.

As an alternative approach to understanding individual decision-making, the ABC research group has developed the idea of simple heuristics (Gigerenzer et al. 1999). They claim that, when dealing with choice problems, rather than maximizing any objective function, people use simple comparison rules. For example, Brandstatter, Gigerenzer, and Hertwig 2006 introduce the priority heuristic that allows for a making of risky choices without trade-offs. This heuristic is capable of predicting the majority of biases observed in the experiments, where subjects need to choose between lotteries. However, it is impossible to distinguish whether subjects use heuristics or maximize some odd objective functions when only information on their actual choices is available. Then, process data becomes important.

As Johnson, Schulte-Mecklenbeck, and Willemsen 2008 propose, process models should be tested using process data. This data can be collected with a tool like Mouselab, which was previously adopted in Johnson, Camerer, Sen, and Rymon 2002 to demonstrate that the subjects deviate from backward induction in sequential bargaining games, and in Gabaix, Laibson, Moloche, and Weinberg 2006 to show that the directed cognition model predicts the sequence of steps in the information acquisition process better than the fully rational model. An alternative process tracking tool, iView, that records eye movements, has been used in Rubinstein, Arieli, and Ben-Ami 2010 to conclude that decision-makers are more likely to compare prizes and their probabilities separately when choosing between lotteries. In the experimental studies reported in this dissertation, I use the Mouselab tool to collect data on the process of choosing three-part tariffs by consumers and to test whether this process can be treated as search.

Chapter 1

Choosing a Three-Part Tariff in a Lab

Standard price discrimination theories are based on the assumption that consumers use their demand estimates to evaluate their net utility from each available payment scheme. Unless they make errors in estimating their demand or evaluating their net utility, consumers always choose the payment scheme with the highest net utility. In this Chapter of the dissertation, I present a laboratory experiment designed to measure how good consumers are in estimating their demand and in evaluating their net utility from offered three-part tariffs and to study how these abilities affect their choice of a three-part tariff. One important result is that subjects need guidance on how to evaluate their net utility in order to do it properly. The second result is that only conditional on making optimal consumption decisions prior to the choice of a three-part tariff can subjects use feedback on such decisions to find the three-part tariff that is the best for their demand type. Both results rely on the process data collected from the experiment using the Mouselab Web.

1.1 Introduction

In many markets, consumers need to choose from a set of complex payment schemes in order to consume a homogeneous good. This appears to be a complicated task, and there is no clear understanding on how consumers undertake it. The standard price discrimination literature implicitly assumes that consumers can always find the best payment scheme by computing and then comparing their expected utility under each available alternative. Given that the choice of payment schemes requires computations that are cognitively costly, the existing search models can be applied to understand it better. The alternative-based search models suggest that consumers will keep searching as long as they believe that they can find a scheme that is sufficiently better than the best from those considered up to the moment. When the best available alternative is not even considered during the search process, such models give an easy explanation why it is not chosen. Still, the alternative-based search models where getting an alternative considered at the early stage of the search process is costless imply that from the set of considered alternatives the best should be always chosen.

Two elements of the described consumer problem are addressed in this paper. First, in the case of complex payment schemes, it largely depends on the consumer's demand which scheme is the best for the consumer. As an example, a scheme with a high bundle of endowed monthly consumption and, consequently, a high monthly fee might be the best option for a consumer with high demand, but not for a consumer who needs little. Assume that the demand is deterministic, and the consumer is not new to the market when he chooses the payment scheme. That is, he can learn his demand from his past experience and use this information to make the optimal choice. The first question posed in this paper is whether consumers do it, and how their ability to do it affects their choice.

Second, in most cases, relevant parameters of all complex payment schemes are immediately available, that is, a consumer does not need to walk from one store to another to learn them. What he needs to do is to process these easily available parameters to infer his utility from each payment scheme. The second question addressed in this paper is whether consumers evaluate payment schemes in such a manner, or whether they apply alternative decision rules, and how this affects their choice of a payment scheme.

Both questions are studied using data from a computer-based laboratory experiment, where a standard consumer problem of choosing a three-part tariff is replicated. The experiment consists of three tasks. In the first and the third tasks, subjects need to make

a sequence of consumption decisions. For each consumption unit offered to them, they need to decide whether to consume it based on the comparison of its value and cost. The sequence of units offered to subjects is the same in both tasks. The difference between tasks is that in the first task, the cost is equal to a fixed per-unit price, while in the third task, the cost is determined by the three-part tariff chosen in the second task. Prior to the experiment, subjects are told about its structure and can infer that learning the sequence of offered consumption units in the first task might be helpful for choosing the optimal tariff in the second task. The subjects' earnings from the first task are observable during the choice of a three-part tariff in the second task, and the experiment is designed such that the sequence of offered units can be inferred from this number, conditional on that the optimal consumption decisions have been made. One of the main experimental results is that those subjects whose consumption decisions in the first task are optimal are more likely to choose the optimal three-part tariff in the second task if they spend more time looking at their earnings from the first task. The same does not hold for those subjects who made more than average sub-optimal decisions in the first task.

The time that subjects spend on looking at one parameter or another is a part of the process data collected in the experiment using a mouse tracking tool, the Mouselab Web. Another part of these data is the sequence in which subjects acquire information on the offered pricing scheme. This sequence allows me to measure what share of each subject's mouse movements can be attributed to evaluating the offered three-part tariffs one-by-one as opposed to comparing them parameter-by-parameter. The data analysis shows that the type of mouse movements is an important determinant of the choice that a subject makes in the second task.

Knowing how consumers choose payment schemes is of interest to regulatory authorities focused on consumer protection. The European Commission's proposal to review the telecom regulatory framework is one example. As a part of the proposed reform, providers of telecom services should be "obliged to publish information on prices so that consumers can more easily compare the different offers on the market." [1] The proposal does not specify what it means for different offers to be more easily comparable.

The paper is organized as follows. In Section 1.2, the consumer problem is formally introduced. In Section 1.3, the experimental design is explained. Section 1.4 contains data analysis and the main results. Concluding remarks are in Section 1.5.

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[1] The proposed reform and reports can be found at http://ec.europa.eu/index_en.htm.

1.2 Consumer Problem

1.2.1 Consumer Problem and Optimal Behavior

In the experimental study reported here, a consumer is assigned three tasks. First, he makes a sequence of consumption decisions. At each moment of time, he is offered a consumption unit with a specified value and cost and is asked whether he wants to take this unit. The deterministic value of a particular unit is either high, v_A, or low, v_B.[2] The deterministic cost of all units is the same and is equal to the fixed per-unit price, P_0.

In Task 2, the consumer has to choose one out of two available three-part tariffs knowing that his choice will determine the cost of consumption in Task 3. The three parts of each tariff are a fixed fee, F_j, to be paid at the beginning of the third task, a bundle of included units, I_j, provided without any additional charge after the fixed fee is paid, and an extra-unit price, P_j, to be paid for each unit consumed in addition to the included units, where $j = 1, 2$ refers to the tariff.[3]

In Task 3, the consumer again needs to make a sequence of consumption decisions. The consumption units have the same values and are offered in the same order as in Task 1; however, the cost of consumption is now determined by the three-part tariff chosen in Task 2.

The idea behind the three tasks introduced above is to imitate a real-life consumer problem in a laboratory setting. When a consumer first enrolls in some service, e.g. mobile phone calling in a new country, in most cases he chooses a flat per-unit price to learn better about his consumption patterns. Once he knows how his consumption looks like, he may choose a more complex tariff plan. Then he continues consuming the service under a new cost function. Consumption units with high and low values can be treated as important and not so important calls.

For the rational consumer, the predicted behavior in each task is the following:

Task 1: Consumption under a flat per-unit price. As the consumption cost is determined by a flat per-unit price, consumption of a particular unit does not affect the

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[2]Despite all the insights into categorical reasoning that we have (see Laurence and Margolis 1999, Murphy 2004 for overviews, and Mohlin 2009 for an attempt to model categorical reasoning), categorization of consumption units is generally not allowed in theoretical literature. This prevents the demand function from being discontinuous. In the experiment, there is no need in a continuous demand function. I intentionally impose the categorization of consumption units. It makes it easier for consumers to remember their consumption patterns.

[3]Plans are numbered such that $F_2 > F_1$. This paper focuses on the case when this implies that $I_2 > I_1$ and $P_2 < P_1$ as is common for mobile phone plans.

cost of subsequent units. In this case, the rational consumer should take all units with a non-negative net value, and only such units. That is, all v_A-units should be consumed if and only if $v_A \geq P_0$, and all v_B-units should be consumed if and only if $v_B \geq P_0$.

Task 2: Choice of a three-part tariff. As the consumer knows that in Task 3 he will face the same sequence of consumption decisions as in Task 1, he should be able to infer his optimal consumption under each available three-part tariff when choosing a tariff. Generally, the optimal consumption under different tariffs is different. Knowing this, the consumer should be able to compute the net values of his consumption under both tariffs. Let A_{ij}^* be the optimal consumption of v_A-units and B_{ij}^* be the optimal consumption of v_B-units under the tariff j for the consumer i. Then, the net consumption value of the tariff j for the consumer i is equal to $v_A * A_{ij}^* + v_B * B_{ij}^* - F_j - P_j * \max\{0, A_{ij}^* + B_{ij}^* - I_j\}$. Optimally, the tariff with the highest net consumption value should be chosen.

Task 3: Consumption under the chosen three-part tariff. When the consumption cost is determined by a three-part tariff, the marginal cost of a particular unit is either zero if the accumulated consumption is below the number of included units, or equal to the extra-unit price if the accumulated consumption has already reached the number of included units. Hence, the consumer has to decide a priori which units and how many of them to consume in Task 3. This decision should be based on the knowledge of the total number of v_A- and v_B-units that will be offered, $\bar{A}_i$ and $\bar{B}_i$ correspondingly, and on the parameters of the tariff j chosen in Task 2.

The first question for the consumer to answer is whether taking all v_A-units is optimal. The answer is affirmative, i.e. $A_{ij}^* = \bar{A}_i$, if the total number of such units does not exceed the number of included units. Otherwise, the answer is still affirmative, i.e. $A_{ij}^* = \bar{A}_i$, if $v_A \geq P_j$, or the optimal consumption of v_A-units is equal to the number of included units, $A_{ij}^* = I_j$, if $v_A < P_j$. The next question to answer concerns the optimal consumption of v_B-units. To answer this question, the consumer should go through the same procedure as just described, but take into account the difference between the number of included units and the optimal number of v_A-units, $I_j - A_{ij}^*$, instead of just the number of included units. If this difference is non-positive, the consumer should take all v_B-units if $v_B \geq P_i$, and none of them otherwise. Formally, the optimal consumption is:

$$A_{ij}^* = \begin{cases} \bar{A}_i \text{ if } v_A \geq P_j \\ \min\{\bar{A}_i, I_j\} \text{ if } v_A < P_j \end{cases}, \tag{1.1}$$

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$$B_{ij}^* = \begin{cases} \bar{B}_i \text{ if } v_B \geq P_j \\ \min\{\bar{B}_i, \max\{I_j - A_{ij}^*, 0\}\} \text{ if } v_B < P_j \end{cases} . \tag{1.2}$$

1.2.2   Possible Deviations from Optimal Behavior

It should be extremely easy for the consumer to behave optimally in Task 1. For every offered unit, he just needs to compare its value, v_A or v_B, with its cost, P_0. It seems that no systematic mistakes may occur at this step. However, the consumer may not remember how many units of each type he has been offered in Task 1, and hence, it might be difficult if not impossible for him to evaluate the optimal consumption and the corresponding net consumption value under the tariffs offered in Task 2. The main question addressed in this paper is how consumers with different abilities to remember the sequence of offered consumption units deal with the choice of the three-part tariff in Task 2.

Two possible scenarios are considered. First, consumers who do not remember exactly how many v_A- and v_B-units they have been offered in Task 1, may use some estimates of these numbers to compute the net consumption values of both tariffs offered in Task 2. Second, they may ignore this information and choose the tariff based on the parameters of the offered tariffs only. In both cases, many arbitrary assumptions have to be made to predict which tariff will be chosen. I make an attempt to avoid such assumptions by introducing specific features of the experimental design described below. Briefly, these features are the Mouselab Web tool that allows the collecting of process data and a questionnaire that reveals how well subjects know their consumption patterns.

In this paper, I evaluate only one decision rule that allows the making of a reasonable choice based solely on the parameters of the offered tariffs. This decision rule was suggested by the participants of the pilot sessions in post-experimental personal interviews. The decision rule includes the following steps: (1) compute how much it costs to consume I_2 under the first tariff, $F_1 + P_1 * (I_2 - I_1)$, (2) take the first tariff if this cost is lower than F_2, and take the second tariff otherwise. This decision rule predicts the same choice for all subjects facing the same set of three-part tariffs and does not depend on their consumption patterns. I call it the demand-neutral decision rule.

1.3 Experiment

1.3.1 Design

To implement the consumer problem introduced in Section 1.2, three corresponding tasks are given to subjects. Subjects are randomly assigned into two demand types, low ($i = L$) or high ($i = H$), and five treatments. The demand types differ in the total number of offered v_A- and v_B-units but not in the value of each unit. In this study, I only consider the case when a higher demand for v_A-units is associated with a higher demand for v_B-units, and I believe that for the question under consideration, that is, how subjects with a different ability to remember their consumption patterns deal with the choice of a three-part tariff, this is not a crucial restriction. Two demand types are needed to vary the importance of remembering the number of v_A- and v_B-units precisely in making the optimal choice of a three-part tariff. As it will become clear later, the high-demand type only needs to remember that he has many enough v_A-units, while the low-demand type needs to have an idea about both lower and upper bounds on the number of v_A-units.

Consumption units are offered to subjects sequentially in the way illustrated in Fig. 1.2, and the sequences are the same for all subjects of the same demand type. At each moment of time, a subject is offered either a v_A-, or a v_B-unit, and within a specified time limit he needs to indicate whether he accepts that unit or not. If he does not indicate anything, it is treated as no acceptance. The parameters used to define consumption values are listed in Table 1.1. The unit price charged in Task 1, P_0, is the same for all subjects and is equal to 6 ECU, making the net value of a v_A-unit equal to 4 ECU, and the net value of a v_B-unit equal to -3 ECU. Hence, the optimal consumption in Task 1 is $A_i^* = \bar{A}_i$ and $B_i^* = 0$ for both types. To equalize the time spent on the consumption task by both types, different time limits are imposed: the low-demand type has 6 seconds to decide whether he is taking an offered unit, and the high-demand type has 4 seconds for this. The total duration of the consumption task is 3 minutes for both types.[4]

After Task 1 is completed but before Task 2 starts, earnings from Task 1 are displayed on the subject's computer screen as illustrated in Fig. 1.3. Sophisticated subjects who optimally consumed all v_A-units and only them in Task 1 can use this information to infer the number of v_A-units offered to them. They just need to divide their earnings by

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[4]This design feature is motivated by a real-life analogue of the consumer problem studied here. The total length of the consumption period is typically the same for all consumers, e.g. one month, but consumers with high demand need to make consumption decisions more often.

the net value of a v_A-unit, $\bar{A}_i = W_i/(v_A - P_0)$, where W_i is earnings from Task 1.

Table 1.1: Parameters defining consumption values for two demand types.

Parameter	Low-demand type	High-demand type
v_A	10 ECU	10 ECU
v_B	3 ECU	3 ECU
$\bar{A}_i$	20 units	30 units
$\bar{B}_i$	10 units	15 units

In Task 2, subjects need to choose one three-part tariff from the two offered to them. The choice is represented to subjects as in Fig. 1.4. It is always the case that Plan 1 is optimal for the low-demand type, and Plan 2 is optimal for the high-demand type. As subjects do not know about the existence of the two types, they cannot use this information in choosing a tariff. The five treatments to which subjects are randomly assigned differ in the parameters of the offered three-part tariffs as shown in Table 1.2. Differences across treatments allow for the using of a between-subject analysis to understand the incorrect choices of three-part tariffs better. These differences are discussed in Section 1.3.2.

Table 1.2: The parameters of three-part tariffs offered in Task 2.

	Treatment 1		Treatment 2		Treatment 3	
	Plan 1	Plan 2	Plan 1	Plan 2	Plan 1	Plan 2
Fixed Fee	120 ECU	200 ECU	120 ECU	200 ECU	120 ECU	180 ECU
Included Units	20 units	30 units	20 units	30 units	20 units	25 units
Extra Unit Price	11 ECU	5 ECU	9 ECU	5 ECU	11 ECU	4 ECU
	Treatment 4		Treatment 5			
	Plan 1	Plan 2	Plan 1	Plan 2		
Fixed Fee	120 ECU	180 ECU	75 ECU	200 ECU		
Included Units	20 units	25 units	15 units	30 units		
Extra Unit Price	9 ECU	4 ECU	9 ECU	5 ECU		

Those subjects who did not manage to learn their consumption patterns in Task 1 might be subjectively uncertain about $\bar{A}_i$ and $\bar{B}_i$. Such subjects might be risk-averse and hence biased towards Plan 2 that has a lower variation in possible consumption cost. To minimize the role of risk aversion and other possible consequences of subjective

uncertainty, subjects are paid a bonus of 20 ECU for choosing the tariff that maximizes their consumption value. Task 2 has a time limit of 15 minutes.

After the tariff is chosen, Task 3 starts. The same sequence of units as in Task 1 is offered to subjects. The consumption values are also the same, but the cost is now determined by the tariff chosen in Task 2. This choice affects the optimal consumption decisions in Task 3. If the optimal tariff is chosen, i.e. Plan 1 by the low-demand type and Plan 2 by the high-demand type, then the optimal consumption is the same as in Task 1, i.e. $A_i^* = \bar{A}_i$ and $B_i^* = 0$ for both types. If a choice error is made in Task 2, then the optimal consumption in Task 3 depends on the treatment. For the low-demand type, in addition to $A_L^* = 20$, it becomes optimal to consume $B_L^* = 10$ in Treatments 1, 2, and 5, and $B_L^* = 5$ in Treatments 3 and 4. For the high-demand type, always consuming $B_H^* = 0$, it becomes optimal to reduce the consumption of v_A-units to $A_H^* = 20$ in Treatments 1 and 3, while consuming $A_H^* = 30$ in Treatments 2, 4, and 5.

Under the chosen parameters of the consumer problem studied in this paper, the optimal behavior leads to the following predictions:

H0-1: *In Task 1, all subjects of the low-demand type consume 20 v_A-units and no v_B-units, and all subjects of the high-demand type consume 30 v_A-units and no v_B-units.*

H0-2: *In Task 2, all subjects of the low-demand type choose Plan 1, and all subjects of the high-demand type choose Plan 2.*

H0-3: *In Task 3, conditional on the optimal choice of a three-part tariff in Task 2, all subjects of the low-demand type consume 20 v_A-units and no v_B-units, and all subjects of the high-demand type consume 30 v_A-units and no v_B-units.*

1.3.2 Variations across Treatments

The variations in the parameters of three-part tariffs across the five experimental treatments presented in Table 1.2 should be treated as minor. In all treatments, it is optimal for the low-demand type to choose Plan 1 and for the high-demand type to choose Plan 2. If they make this choice optimally, then they should consume $A_i^* = \bar{A}_i$ and $B_i^* = 0$ in Task 3. The corresponding payoffs are 80 ECU and 100 ECU (not counting for the bonus of 20 ECU for the correct choice in Task 2).

The cost of a choice error in Task 2 and the subsequent optimal consumption in Task 3 slightly vary across treatments. This is reflected in Table 1.3. As it follows immediately, the cost of a choice error for the low-demand type is 50 ECU in Treatments 1, 2, and 5

and 45 ECU in Treatments 3 and 4. The cost of a choice error for the high-demand type is 20 ECU in Treatments 1 and 3 and 10 ECU in Treatments 2, 4, and 5.

Table 1.3: Optimal consumption and the corresponding payoff in Task 3 depending on the tariff choice in Task 2 and the treatment.

	Treatment 1		Treatment 2		Treatment 3		Treatment 4		Treatment 5	
	Plan 1	Plan 2	Plan 1	Plan 2	Plan 1	Plan 2	Plan 1	Plan 2	Plan 1	Plan 2
	Low-demand type									
A_L^*	20	20	20	20	20	20	20	20	20	20
B_L^*	0	10	0	10	0	5	0	5	0	10
payoff	80	30	80	30	80	35	80	35	80	30
	High-demand type									
A_H^*	20	30	30	30	20	30	30	30	30	30
B_H^*	0	0	0	0	0	0	0	0	0	0
payoff	80	100	90	100	80	100	90	100	90	100

One potential reason for a choice error in Task 2 is that the difference in the subsequent payoffs is too small for subjects to notice it. This leads to the following testable hypothesis (the null-hypothesis being that subjects make no choice errors):

HA-1: *Other things being equal, a choice error is more likely when its cost is smaller.*

Practically, this hypothesis implies three things. First, subjects of the high-demand type are expected to make more choice errors than subjects of the low-demand type. Second, subjects of the low-demand type are expected to make more choice errors in Treatments 3 and 4. Third, subjects of the high-demand type are expected to make more choice errors in Treatments 2, 4, and 5.

Another potential reason for a choice error in Task 2 is suggested by the participants of the pilot sessions, as described at the end of Section 1.2. This reason is that a subject relies on a decision rule that does not take into account his demand type. Particularly, the tariff choice is based only on the consumption cost of the included bundle of Plan 2. This cost is simply F_2 under Plan 2, and it is equal to $F_1 + P_1 * (I_2 - I_1)$ under Plan 1. These costs and predicted choices for all treatments are presented in Table 1.4.

To evaluate how likely this decision rule is to explain the subjects' behavior, the following alternative hypothesis is tested:

HA-2: *Other things being equal, subjects are more likely to choose Plan 1 when $F_1 + P_1 * (I_2 - I_1) < F_2$ and more likely to choose Plan 2 when the opposite is true.*

Translated into the proportion of expected choice errors, this hypothesis implies that the low-demand type would be more likely to make a choice error in Treatments 1, 2,

Table 1.4: Cost of consuming included units of Plan 2 and predicted choice under the demand-neutral decision rule across treatments.

	Treatment 1		Treatment 2		Treatment 3		Treatment 4		Treatment 5	
	Plan 1	Plan 2	Plan 1	Plan 2	Plan 1	Plan 2	Plan 1	Plan 2	Plan 1	Plan 2
cost	230	200	210	200	175	180	165	180	210	200
choice		x		x	x		x			x

and 5, and the high-demand type would be more likely to make a choice error in Treatments 3 and 4. Interestingly, for the low-demand type this is exactly the opposite to what the previous hypothesis implies.

The discussion above summarizes how variations across treatments can be used in between-subject analysis to infer what reasons cause potential errors in the choice of a three-part tariff. The main idea is that when enough variation in the parameters of tariffs is introduced, different decision rules give different predictions for the difference in error rates across treatments. As the experiment reported here is one of the first attempting to replicate a consumer problem of choosing a three-part tariff in a laboratory setting, its main purpose is to develop a research method rather than to make strong claims about validity of particular explanations. Hence, I do not introduce more alternative decision rules that could be potentially tested. Instead, I develop another feature of the experimental design that can be used for a better understanding of consumer behavior. This feature is the usage of the Mouselab Web tool described below.

1.3.3 Process Data

As Johnson et al. 2008 propose, a better understanding of the subjects' decisions can be achieved by using process data together with outcome data. One way to collect process data is by using the Mouselab Web tool.[5] The three-part tariffs are presented to subjects in Task 2 as illustrated in Fig. 1.4. Each cell of the table is covered with its label, and to see its value, a subject needs to point at the corresponding label with his mouse. The cell remains open as long as the mouse is pointed at it. The Mouselab Web tool records all mouse transitions between the cells of the table. With this data, a researcher knows in which sequence each subject acquired the information, as well as how often and for how long each cell was opened.

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[5]An example of a Mouselab Web table can be found at http://www.mouselabweb.org.

To use the data collected with the Mouselab Web, one needs to believe that subjects process information in the same order as they acquire it. Such a belief is supported by other economists using the Mouselab Web tool.[6] However, a so-called reading effect should be controlled for (see Brandstatter et al. 2006 and Gabaix et al. 2006). The essence of the reading effect is that subjects tend to move the mouse from left to right and from up to down without processing the information acquired this way.

Typically, the reading effect is minimized by randomizing the order in which the information is presented to subjects. I chose not to randomize this order so as to stay close to a real-life representation of three-part tariffs. Alternatively, Klayman 1983 and Johnson et al. 2008 separate reading and choice phases of the information acquisition process. They do so by casting away all the transitions made before important pieces of information have been examined at least once. In my case, this solution would leave too few observations for the analysis, hence I propose a different solution to control for the reading effect.

My solution is based on the assumption that if a subject has a tendency to move the mouse in a certain direction, this has a permanent effect on his mouse movements. The idea is to induce subjects to evaluate their payoff separately under each three-part tariff, and to record how they move the mouse during this process. I call this induced process the evaluative stage of the tariff choice, as opposed to the natural stage that takes place when subjects are only asked to choose the tariff that would maximize their payoff in Task 3. A comparison of the subjects' mouse movements at the evaluative and natural stages can suggest what they actually do when making a choice.

To implement the evaluative stage, a questionnaire with the steps needed to compute the payoff under each pricing scheme follows the table with the offered three-part tariffs (Fig. 1.5).[7] To see the questionnaire, subjects need to scroll down the page in Task 2. This set-up allows me to assume that subjects see the questionnaire only after they decide which tariff to choose. I, therefore, use the moment when the questionnaire is addressed

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[6]Previously, the Mouselab Web was used in Costa-Gomes, Crawford, and Broseta 2001, Costa-Gomes and Crawford 2006, Gabaix et al. 2006, Johnson et al. 2002, Johnson et al. 2008. Costa-Gomes et al. 2001 and Costa-Gomes and Crawford 2006 illustrate that the distortions in choices caused by the Mouselab environment, and in particular, the fact that to acquire information a subject needs to move his mouse, are minimal.

[7]Answering the posed questions is voluntary. However, subjects are told that this might help in finding the correct plan. 50 subjects answered all questions, 16 others answered none of them. The choice error is insignificantly higher among those who answered all questions (36%) compared to those who answered none (25%). Surprising at first sight, this observation might be interpreted as those who were confident in their choice being correct had no interest in improving it.

for the first time as the separation between the natural and the evaluative stages. This moment is captured by the Mouselab Web tool.

Using the process data separated into the natural and the evaluative stages, I can check whether subjects tend to make choice errors in Task 2 because they do not evaluate their payoffs under the offered three-part tariffs properly. For that, I claim that a subject needs to move the mouse between the scheme's parameters to evaluate his payoff under this scheme. These are vertical movements. Counting such movements at the evaluative stage indicates how many of them, relative to other types of movements, a subject needs to evaluate his payoff. Comparing the shares of vertical movements at the natural and the evaluative stages indicates how likely a subject is to evaluate his payoffs under the offered three-part tariffs when choosing between them. Having this indicator, the following hypothesis can be tested.

H1-3: *Other things being equal, subjects who are more likely to evaluate their earnings under the offered three-part tariffs are more likely to choose the optimal tariff.*

1.3.4 Subjective Demand Uncertainty

At this moment, it is important to come back to the issue of subjective demand uncertainty. Even though subjects are explicitly and *a priori* told that the sequence of offered units is the same in Task 1 and Task 3, some of them do not memorize this sequence in Task 1 and hence are subjectively uncertain about their future consumption when choosing a three-part tariff in Task 2. They can, in principle, estimate the number of v_A- and v_B-units offered to them and use these estimates to evaluate their payoffs under the offered three-part tariffs.

Estimating the total number of offered v_A-units is easier for subjects who make fewer sub-optimal decisions in Task 1, i.e. consume almost all v_A-units and almost none v_B-units. In this case, dividing the payoff from Task 1 by the net value of a v_A-unit gives a good idea about the total number of offered v_A-units. Time spent on observing the payoff from Task 1 can serve as an indicator whether subjects use this approach to estimate the total number of offered v_A-units. Under the implicit assumption that knowing this number helps in finding the optimal three-part tariff, this leads to the following hypothesis.

H1-4: *Other things being equal, subjects with relatively few errors in Task 1 who spend more time on analyzing their payoff from Task 1 are more likely to choose the optimal three-part tariff in Task 2.*

1.3.5 Implementation

Six experimental sessions to collect data were conducted at the CERGE-EI computer lab with 20 machines in April - June 2009. Subjects were students of Charles University in Prague recruited through the ORSEE system.[8] A total of 96 subjects participated in the experiment, 61 of them were males and 59 studied either economics or business administration. Subjects were paid in CZK.[9] The average earnings were 525 CZK in Sessions 1-2, 385 CZK in Sessions 3-4, and 560 CZK in Sessions 5-6.[10]

A page with general information about the experiment (see Fig. 1.1) was opened at each computer screen before subjects entered the lab. This part of the instructions was read aloud. Importantly, subjects were told at the very beginning, and it was repeated later on, that they would have to complete two identical consumption tasks with the only difference being that in the later task, their consumption costs would be determined by their own choice of a three-part tariff. From this statement, they could infer that remembering the sequence of consumption units offered in Task 1 might be useful. Subjects were assured that everyone could earn the same amount and that their earnings would depend on their own performance but not on the performance of others.[11]

Afterwards, subjects proceeded at their individual pace and read the detailed instructions themselves. Particularly, they learned the exchange rate between ECU and CZK privately, as this rate was different for subjects of the low- and high-demand types. The exchange rates were 2 CZK to 1 ECU for the low-demand type and 1.5 CZK to 1 ECU for the high-demand type in Sessions 1-4 and 3.2 CZK to 1 ECU for the low-demand type and 2.4 CZK to 1 ECU for the high-demand type in Sessions 5-6. The maximum possible payoffs from the experimental tasks were 360 CZK in Sessions 1-4 and 580 CZK in Sessions 5-6. Due to various possibilities of additional earnings, the maximum possible overall payoffs were 610 CZK in Sessions 1-2, 460 CZK in Sessions 3-4, and 680 CZK in Sessions 5-6.[12]

Before the detailed instructions were displayed, subjects were asked to complete a

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[8]Subjects could register at http://www.experimenty.eu/public/.

[9]The exchange rate was 1 CZK for approximately 0.05 USD at the time of the experiment.

[10]See below why and how the maximum possible earnings varied across these sessions.

[11]The maximum possible earnings varied across sessions though as the value of subjects' time was potentially higher in the later sessions conducted during the exam period.

[12]In addition to the performance-based payoff, the subjects received 50 CZK for completing a personality quiz prior to the experiment. Also, they received 50 CZK for answering a set of questions at the end of the experiment in Sessions 3-6 and on average 210 CZK for participating in an additional experiment that took about 30 min in Sessions 1-2.

personality quiz. After subjects read the detailed instructions, they were asked to fill in missing values in two practice examples. To make sure that the instructions were understood correctly, it was not possible to proceed until correct answers were submitted.[13] After the experiment was over, each subject was asked to fill in a final questionnaire and was paid afterwards. The experiment, including reading the instructions and filling in the questionnaires, took, on average, about one hour.

1.4 Results

Of the 96 subjects that participated in the experiment, 32 made a choice error in Task 2. This clearly rejects hypothesis H0-2 of no choice errors in Task 2.[14] The distribution of incorrect choices across demand types and treatments is shown in Table 1.5. Using this distribution, one can test for the hypotheses formulated in Section 1.3.2.

Table 1.5: The distribution of incorrect choices across demand types and treatments

	T1		T2		T3		T4		T5		Total	
	low	high	low	high	low	high	low	high	low	high	low	high
# choice errors	4	3	7	3	1	4	1	1	5	2	18	13
# choices	11	9	16	15	10	10	4	5	8	8	49	47
	Total: 20		Total: 31		Total: 20		Total: 9		Total: 16		Total: 96	

The hypotheses testing relies on the Fisher's Exact Test. To test hypothesis HA-1, the error rates between the low-demand type (high cost) and the high-demand type (low cost), between the low-demand type in Treatments 1, 2, and 5 (high cost) and in Treatments 3 and 4 (low cost), and between the high-demand type in Treatments 1 and 3 (high cost) and in Treatments 2, 4, and 5 (low-cost) are compared. The comparison is shown in Table 1.6. In each test, the null-hypothesis is that there is no variation in the error rate across the groups. This is tested against a one-sided alternative that the error rate is higher for the groups with a lower cost of making a choice error. From these three tests it follows that a higher cost of a choice error does not reduce its probability.

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[13]Contact the author for the complete set of instructions and practice examples.

[14]In Task 1, the average share of not taken v_A-units is 9.9%, and the average share of taken v_B-units is 13.9%, which rejects hypothesis H0-1 of optimal behavior in Task 1. For those subjects who choose the optimal three-part tariff in Task 2, the average share of not taken v_A-units is 4.9%, and the average share of taken v_B-units is 12.6% in Task 3. This is lower than the error rate of the same subjects in Task 1 but still not low enough not to reject hypothesis H0-3.

Table 1.6: Fisher's Exact Tests for the differences in the error rate between groups with different costs of making a choice error. The p-value listed first is the probability that the null is true when compared to the alternative that the error rate is higher when its cost is lower. The p-value listed in parentheses is the probability that the null is true when compared to the alternative that the error rate is higher when its cost is higher.

	All subjects		Low-demand type		High-demand type	
	high demand	low demand	low cost	high cost	low cost	high cost
Choice error	**13**	18	**2**	16	**6**	7
No choice error	34	**31**	12	**19**	22	**12**
1-tail p-values	.88 (**.23**)		.99 (**.04**)		.93 (**.2**)	

Result 1: *When the cost of a choice error increases, subjects become more prone to choice errors. The effect is statistically significant for the low-demand subjects.*

Under the assumption that choice errors are due to a random noise in the subjects' evaluation of their payoffs from the offered three-part tariffs, the result just reported is counterintuitive. One would expect the opposite relation between the cost of a choice error and its rate if the assumption was true. With the observed pattern, it becomes clear that a random noise in the subjects' evaluation of their payoffs is not the strongest determinant of choice errors. In fact, the result becomes more intuitive when one remembers that for the low-demand type, the treatments with a higher cost of a choice error were also those where the demand-neutral decision rule predicts an incorrect choice for them.

This demand-neutral decision rule suggested by the participants of the pilot sessions is to choose the tariff with the lowest cost of consuming the included bundle of Plan 2. It predicts that Plan 1 should be chosen in Treatments 3 and 4, and Plan 2 should be chosen in the remaining treatments. Hence, the error rate of the low-demand type whose optimal choice is always Plan 1 should be lower in Treatments 3 and 4, and the opposite should be the case for the high-demand type whose optimal choice is always Plan 2 (see hypothesis HA-2). The corresponding Fisher's Exact Tests are presented in Table 1.7. They partially support the demand-neutral decision rule.

Result 2: *The error rate is higher when the demand-neutral decision rule predicts that a sub-optimal three-part tariff should be chosen. The difference is statistically significant for the low-demand subjects.*

Other decision rules could be considered and evaluated here, but as the paper focuses more on methodology, I move instead to the analysis of the collected process data. Using these data, first the method proposed in Section 1.3.3 is used to construct a variable

Table 1.7: Fisher's Exact Tests for the validity of the demand-neutral decision rule. The listed p-value is the probability that the null is true when compared to the alternative that the demand-neutral decision rule predicts correctly.

	Low-demand type		High-demand type	
	predicted high error rate	predicted low error rate	predicted high error rate	predicted low error rate
Choice error	**16**	2	**5**	8
No choice error	19	**12**	10	**24**
1-tail p-values	**.04**		**.4**	

that measures how likely a subject is to evaluate his payoff under each tariff separately. Within this method, the shares of vertical mouse movements (i.e. between the parameters of one three-part tariff) at the natural and at the evaluative stages of the tariff choice are compared. To reduce the noise caused by random mouse movements, only three consequent mouse movements within the same three-part tariff are considered as evaluative movements. As it follows from Table 1.8, the share of such evaluative mouse movements is by 9 p.p. higher at the evaluative stage of the choice process. In the later analysis, individual differences in the shares of evaluative mouse movements between the evaluative and the natural stages of the choice process are used. As one can see from Table 1.8, for more than a quarter of subjects this difference is negative. For subjects with the negative difference, the average share of evaluative movements is higher at the natural stage (27% vs. 13.1%) and lower at the evaluative stage (16.5% vs. 29.8%) than for subjects with the positive difference. It appears that the error rate in Task 2 is significantly higher for subjects with a negative difference (50%) than for subjects with a positive difference (26.5%). It is not really clear why this is the case. Potentially, a positive difference reveals those for whom the questionnaire, i.e. the evaluative stage, helps them to make a correct choice of a three-part tariff.

Table 1.8: Mouse movements during the choice of a three-part tariff.

	Share of evaluative mouse movements		Individual difference in shares	
	Natural stage	Evaluative stage	between evaluative and natural stages	
mean	.167	.257	negative	26 subjects
s.e.	(.013)	(.015)	maximum	68 subjects
# observations	91		mean	.09
paired t-test	-5.16***		st. dev.	(.167)
***1% significance level				

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Next, I measure the effect of the subjects' subjective uncertainty on their choice of three-part tariffs in Task 2. First, the subjective uncertainty needs to be measured. It is done by computing the proportions of not taken v_A-units and taken v_B-units for each subject. The sum of the two is used as a measure of subjective uncertainty. Its highest possible value is 2 when no v_A-units and all v_B-units are taken, and the lowest is 0 when there are no errors in Task 1. The highest observed value is 1.

As expected, there is a positive correlation between errors in Task 1 and Task 2 (.371). At the same time, there is a strong negative correlation between errors in Task 1 and the shares of evaluative mouse movements at both the natural (-.211) and evaluative (-.346) stages of the choice process. The correlation between errors in Task 1 and the difference in the shares of evaluative mouse movements at the two stages is weaker (-.142). This suggests that there might be a non-trivial effect of subjective demand uncertainty caused by sub-optimal behavior in Task 1 on the choice of a three-part tariff in Task 2. To illustrate this point, subjects are divided into four groups based on two criteria. The first criterion is whether the difference in the shares of evaluative mouse movements is positive, and the second criterion is whether errors in Task 1 are above the average, which is roughly .25. The average error rate in Task 2 is computed for each group (Table 1.9).

Table 1.9: The error rate in Task 2 by errors in Task 1 and mouse movements in Task 2.

| | Evaluative mouse movements at evaluative and natural stages | | |
Errors in Task 1	negative difference	positive difference	t-test
≤ .25	43.8%	13.3%	2.2**
> .25	60%	52.2%	.4
t-test	-.78	-3.29***	

Remember that the average error rate in Task 2 is 33.3%. It follows from Table 1.9 that the error rate in Task 2 is below the average only for those subjects who both made relatively few errors in Task 1 and made more evaluative mouse movements when answering the questionnaire than when choosing a three-part tariff naturally.

Before moving to the regression analysis, I introduce another variable that can potentially explain the sub-optimal choice of a three-part tariff. As mentioned above, subjects can infer the number of v_A- and v_B-units that will be offered to them in Task 3 from their earnings in Task 1. The time they spend on looking at their earnings from Task 1 can be used as an indicator whether they used this information when choosing a three-part

tariff. They can see the earnings from Task 1 on a separate screen after Task 1 is over, before Task 2 starts (Fig. 1.3), and in the corresponding cell of the table displayed in Task 2 (Fig. 1.4). To control for the fact that some subjects generally spend more time on processing information than others, the share of the time spent on observing earnings from Task 1 is computed. This share is higher for those who chose the right three-part tariff (3.6%) than for those who made a choice error (2.6%).

Table 1.10: The error rate in Task 2 by errors in Task 1 and relative time spent on observing earnings from Task 1.

	Share of time spent on observing earnings		
Error measure in Task 1	$\leq 3.2\%$	$> 3.2\%$	t-test
$\leq .25$	27%	12%	1.43*
$> .25$	57.1%	53.8%	.18
t-test	-2.34**	-3.03***	

Supposedly, to infer any useful information from the level of earnings in Task 1, it is important not to make too many errors in Task 1, as discussed in Section 1.3.4. To illustrate the joint effect from errors in Task 1 and time spent on observing earnings from Task 1 on the error rate in Task 2, subjects are again divided into four groups, and the error rate in Task 2 is computed for each group (Table 1.10). It follows that only those subjects with less than an average share of sub-optimal decisions in Task 1 can increase the probability of choosing the optimal three-part tariff by spending more time on observing their earnings in Task 1.

Based on the observation that choice errors in Task 2 can be explained differently depending on the subjects' performance in Task 1 (as it follows from Table 1.9 and Table 1.10), a regression analysis is done separately for those with the error measure in Task 1 below and above the average. The results are in Table 1.11.

Results presented in Table 1.11 allow for the testing of the hypotheses from Section 1.3.3 and Section 1.3.4. First, hypothesis H1-3 suggests that evaluating earnings from the offered three-part tariffs helps in choosing the optimal tariff. The experimental data give indirect evidence for this when we look at the sign of the coefficient on the share of evaluative mouse movements at the evaluative stage of the choice process.

Result 3: *Other things being equal, the subjects who are more likely to evaluate their earnings under the offered three-part tariffs when they are guided to do so, are less likely to choose a sub-optimal tariff.*

Table 1.11: Probit for the sub-optimal choice of a three-part tariff.

| | Sub-optimal choice of a three-part tariff | | |
| | Error measure in Task 1 | | |
Dependent variable	$\leq .25$	$> .25$	all subjects
Cost of choice error	.0004	.007	.0006
	(.003)	(.007)	(.003)
# attempts in Test 1	-.012	-.423***	-.07
	(.026)	(.134)	(.047)
# attempts in Test 2	.008	.122*	.026
	(.024)	(.064)	(.025)
Share of evaluative movements	.587*	1.011	.577
at natural stage	(.356)	(1.113)	(.421)
Share of evaluative movements	-.651*	-.797	-.699*
at evaluative stage	(.378)	(.932)	(.387)
Share of time spent on	-5.22**	-.268	-5.693**
observing earnings from Task 1	(2.5)	(6.664)	(2.548)
Errors in Task 1	-	-	.393**
	-	-	(.199)
predicted P	.151	.517	.261
# observations	60	30	90

<div align="center">

* - 10% significance level

** - 5% significance level

*** - 1% significance level

</div>

Entries are the marginal effects.

Standard errors clustered at the subject level are in parentheses.

However, as the coefficient on the share of evaluative mouse movements at the natural stage of the choice process reveals, when subjects seem to evaluate their earnings from the offered three-part tariffs without guidance, they are more likely to choose a sub-optimal tariff. A potential explanation is that subjects are not used to evaluating three-part tariffs properly in their regular life.

Second, hypothesis H1-4 suggests that subjects with a relatively low error rate in Task 1 are more likely to choose the optimal three-part tariff if they spend relatively more time looking at their earnings from Task 1. This has strong support in the data.

Result 4: *Other things being equal, the subjects with lower-than-average error measure in Task 1 are less likely to choose a sub-optimal tariff if they spend relatively more time on observing their earnings from Task 1. This time has no significant effect for subjects with a higher-than-average error measure in Task 1.*

The most compelling explanation for the reported result is that, conditional on making optimal decisions in Task 1, subjects can infer the number of offered v_A-units from their earnings in Task 1, and this information proves to be helpful in finding the optimal tariff.

1.5 Conclusion

Chapter 1 of this dissertation reports the results of a laboratory experiment designed to understand the consumers' choice of three-part tariffs (i.e. payment schemes that have a fixed fee, a bundle of included units, and an extra-unit price). In the experiment, subjects need to complete three interrelated tasks. The first and the third tasks attempt to replicate the consumption of a service like mobile phone calling. There are two categories of consumption units that subjects face, with either low, or high consumption value, to imitate important and not important calls that consumers can potentially make. Subjects have no control over the sequence in which potential consumption units arrive, but they are to decide whether to consume a particular unit once it arrives.

The sequences of consumption units that subjects are offered in the two consumption tasks are identical. The difference between tasks is the way subjects pay for their consumption. In the first task, each unit has the same fixed price, while in the third task the cost is determined by the three-part tariff chosen in the second experimental task. Subjects are aware of the structure of the game from the beginning, and they can anticipate that learning the sequence of consumption units offered to them in the first task might be helpful for the choice of a three-part tariff in the second task. The main question addressed in the paper is how the observed 33.3% error rate in the choice of a three-part tariff can be explained.

The main advantage of studying the choice of a three-part tariff, so common in real life, using a laboratory experiment is the possibility of collecting process data. The tool that allows us to do this is the Mouselab Web. It records all mouse movements during the process of acquiring information on the offered three-part tariffs and on the time spent on a particular task. By using the collected process data, it is possible to create two important measures. The first measure relies on the fact that to evaluate payoffs associated with each three-part tariff, a subject needs to focus on the parameters of one tariff in isolation from the parameters of the other tariff. So, this measure is the share of mouse movements within one tariff in the total number of mouse movements. The second measure relies on the fact that, conditional on making optimal decisions in the

consumption task, the subject can infer the important information on their consumption patterns from observing the payoff from the consumption task. Hence, the second measure is the share of time spent on looking at the payoff from the consumption task from the time spent overall on the choice of a three-part tariff.

The following two results are the most interesting. First, until subjects are provided guidance on how to evaluate the offered three-part tariffs, it does not help them to find the optimal tariff if they focus on evaluating tariffs one by one. Second, unless subjects make an optimal consumption decision, having feedback on those decisions does not help them to find the optimal tariff. This leads to the corresponding policy implications: First, providing consumers with monthly bills does not necessarily help them to improve upon their choice of tariff. Second, suggesting to consumers on how to evaluate existing market alternatives might be very efficient.

1.6 Appendix

Figure 1.1: Screen-shot of the welcome page.

Welcome to the Experiment!

The purpose of this experiment is to understand how consumers choose pricing schemes, mobile phone plans being an example of such schemes. Hence we will ask you to choose a plan similar to a mobile phone plan, in one of the experimental tasks described below. Altogether there will be three tasks, the other two tasks having a supporting role that will become clear after you read the whole set of instructions:

- **Task 1: Consumption**. In this task, you will be buying "actions" in a way described later on. You will pay a constant price for each "action" that you buy.

- **Task 2: Plan Choice**. In this task, you will choose a plan that will determine how you will pay for the "actions" that you will buy in **Task 3.**

- **Task 3: Consumption again**. In this task, you will be buying "actions" in a similar way as in **Task 1**. The only difference will be that, rather than paying a constant price for each "action" that you buy, you will pay according to the plan that you will choose in **Task 2**.

Before you see the whole set of instructions and start the experiment, we will ask you to fill up a questionnaire. There are **15 questions** in the questionnaire. For answering them you will receive **50 CZK**. It will be possible to earn up to **580 CZK** in addition to that through your performance on the three tasks of the experiment. For answering a set of questions after the experiment is over, you will receive additional **50 CZK**. Thus, the maximum that you can earn is **680 CZK**, including **100 CZK** that is independent of your performance.

After you complete the questionnaire, instructions will apear on your screen. Read them carefully and proceed as it is suggested by the instructions. Do not wait for others. Note that your performance is not affected by the performance of other participants, neither it affects their performance.

If you have any questions or technical problems during the experiment, raise your hand and the experimenter will come to you.

Do not talk to each other and do not make any notes during the experiment.

You are not allowed to use any additional computer applications or web-pages.

After you finish the experiment and see your final payoff on the screen, raise your hand and the experimenter will come to you.

Please, enter the name and the password (case sensitive), which are given to you, and click on the **"ENTER"** button to move to the **questionnaire**.

Your name: Russia

Password: ●●●●●●

ENTER

Figure 1.2: Screen-shot of Task 1. "Action" stands for "unit" here.

Figure 1.3: Screen-shot of Task 1. Displayed wealth.

Figure 1.4: Screen shot of Task 2; natural stage.

Task 2: Plan Choice

You have **15 minutes** for completing this task.

This timer shows how much time has passed: | 1 min : 3 sec |

After the time expires, all cells will become inactive. Then choose one of the two plans to continue the experiment.

You may also choose a plan and move to **Task 3: Consumption Again** before the time expires.

Two plans of the same three-part structure are offered to you. You may learn the parameters of these plans from the table below.

To check the content of a cell, point out the mouse at it:

Plan 1	Plan 2		Benefit from Action A
Fixed Fee 1	Fixed Fee 2		Benefit from Action B
Inclusive Actions 1	Inclusive Actions 2		Bonus
Unit Price 1	Unit Price 2		Your Wealth

The parameters of the plans have the following meaning:

- A **Fixed Fee** is similar to the monthly fee in mobile phone plans:
  - **Fixed Fee 1** specifies how much you have to pay for getting **Inclusive Actions** in **Task 3: Consumption Again** if you choose Plan 1.
  - **Fixed Fee 2** specifies how much you have to pay for getting **Inclusive Actions** in **Task 3: Consumption Again** if you choose Plan 2.

- **Inclusive Actions** are similar to the inclusive minutes in mobile phone plans:
  - **Inclusive Actions 1** specify how many actions in **Task 3: Consumption Again** you will get "for free", that is, without paying a **Unit Price** for them, if you choose Plan 1.
  - **Inclusive Actions 2** specify how many actions in **Task 3: Consumption Again** you will get "for free", that is, without paying a **Unit Price** for them, if you choose Plan 2.

- A **Unit Price** is similar to the unit price in mobile phone plans:
  - **Unit Price 1** specifies how much you have to pay for every action that you decide to buy in **Task 3: Consumption Again** after the **Inclusive Actions** are over if you choose Plan 1.
  - **Unit Price 2** specifies how much you have to pay for every action that you decide to buy in **Task 3: Consumption Again** after the **Inclusive Actions** are over if you choose Plan 2.

Also, you may check **Benefits** from actions A and B specified by your demand profile and your current **Wealth** in the table.

Of the two plans offered to you, one is more suitable for your demand profile than the other. If you make a correct choice, you will be paid a **Bonus** after you complete the subsequent **Task 3**.

Figure 1.5: Screen shot of Task 2; evaluative stage.

Answering the following questions may help you to choose the right plan. Specify your answers in the empty fields (optionally):

First, answer these questions assuming that you will choose Plan 1:

What will be you consumption strategy in Task 3 if you choose Plan 1: | |

How many actions A will you buy in Task 3 if you choose Plan 1: | | actions

How many actions B will you buy in Task 3 if you choose Plan 1: | | actions

What will be your total benefit from this consumption in Task 3 if you choose Plan 1: | | ECUs

What will be your total expenditure on this consumption in Task 3 if you choose Plan 1: | | ECUs

What will be your payoff (net benefit) in Task 3 if you choose Plan 1: | | ECUs

Now, answer the same questions assuming that you will choose Plan 2:

What will be you consumption strategy in Task 3 if you choose Plan 2: | |

How many actions A will you buy in Task 3 if you choose Plan 2: | | actions

How many actions B will you buy in Task 3 if you choose Plan 2: | | actions

What will be your total benefit from this consumption in Task 3 if you choose Plan 2: | | ECUs

What will be your total expenditure on this consumption in Task 3 if you choose Plan 2: | | ECUs

What will be your payoff (net benefit) in Task 3 if you choose Plan 2: | | ECUs

Chapter 2

Heuristics That Consumers Use for Evaluating Costs of Three-Part Tariffs

I use experimental data to understand how consumers choose three-part tariffs, i.e. pricing schemes characterized with a fixed fee, a bundle of included units, and an extra-unit price, when their demand is perfectly inelastic but uncertain. The consumer problem replicated in the experiment is specific in a sense that consumers' expected demand is always equal to the number of included units under one of the four offered tariffs. As a result, the cost function of this tariff is always convex over the possible demand range, while this is not the case for other tariffs. Depending on what heuristic is used in the choice of a three-part tariff, the cost under such a tariff might be over- or under-estimated by consumers. The observed bias towards such a tariff suggests that the latter is the case. In addition, an analysis of the process data collected with the Mouselab tool suggests that the choice of a three-part tariff can be treated as a search, and that subjects use parameters of the offered tariffs to infer the associated consumption costs.

2.1 Introduction

Consumer life is full of choices. Often, consumers face the problem of choosing a multi-part pricing scheme. Examples include tariffs for utilities and telecoms services, credit card contracts, saving and insurance plans, and many others, up to packages of different size in supermarkets. In this paper, I present a laboratory experiment designed to investigate whether consumers make such choices optimally, what factors can explain potential deviations from optimality, and how the efficiency of consumers' choices can be improved.

The experiment used in this paper is built upon the example of mobile phone tariffs actually existing in the Czech Republic. The tariffs from one of the main operators are presented in Fig.2.1, where omitted prices are the same across tariffs.

Figure 2.1: Example of mobile phone plans in the Czech Republic, 2007, prices in CZK.

	T 30		T 80		T 250	
	HIT	standard	HIT	standard	HIT	standard
Monthly fee		190		450		990
Free minutes		30		80		250
Free SMS		0/20*		0/20*		0/20*
T-Mobile	3.20	4.00	2.80	3.50	2.80	3.50
Other networks	4.80	6.00	3.60	4.50		

To see why this example is interesting, one needs to compute how much it costs to consume 80 minutes per month, which are free minutes of the tariff $T80$, with tariffs $T30$ and $T80$. For the tariff $T30$, assume that 50% of calls are within the network, and 50% of calls are to other networks. Then 80 minutes cost $CZK440$ with the tariff $T30$, which is less than $CZK450$ with the tariff $T80$. When a higher portion of calls are within the network, then the tariff $T30$ is even cheaper. Having less than 50% of calls within the network is unlikely for a consumer who considers these tariffs because in this case, tariffs of other mobile operators are more attractive and more likely to be considered. So, the tariff $T80$ that, before any computations are made, looks good for making 80 minutes of calls per month is generally not the cheapest for such consumption.

This example raises a natural question whether consumers who call 80 minutes per month choose the tariff $T80$ despite the fact that it is more expensive for them than the tariff $T30$. Answering this question is important for at least two reasons. The first

one is related to developments in the contract design literature.[1] A typical model in this literature assumes that consumers who call 80 minutes per month would always choose the tariff $T30$ as it is the cheapest for them. If some consumers rely on the framing of tariffs when making judgments about their costs, e.g. consumers who call 80 minutes per month mistakenly believe that the tariff with 80 free minutes is the cheapest for them, then firms may use such framing to relax the incentive compatibility constraint and to achieve higher profits. Hence, an alternative contract design problem can be constructed and theoretically solved.

The second reason to study consumers' choices of pricing schemes is related to consumer protection. The European Commission is one of the authorities that cares about this. It proposes a regulatory measure that would ensure that consumers of telecoms services can easily access and compare information on prices, but does not specify the details of such a measure. Moreover, making information on prices easily available and comparable does not necessarily prevent consumers from choice errors, as this paper suggests. The Office of Fair Trading in London is another authority interested in price regulations that would help consumers to avoid choice errors. They commissioned a report on the impact of price frames that was based on a controlled economic experiment done by Huck and Wallace 2010. The experiment shows that various price frames distort consumers' decisions on how much to search and how much to buy and result in overall welfare losses. The framing of tariffs described above and studied in this paper has not been considered in the reported experiment.

In this paper, I also use a laboratory experiment to address the question of interest. It has several advantages over using the field data as an increasing number of studies do.[2] A typical dataset from the field would contain individual choices of pricing schemes as well as preceding and subsequent consumption levels. Using information on the realized consumption and the available pricing schemes at the moment of choice, a researcher can conclude whether individual choices of pricing schemes are ex-post sub-optimal, i.e. whether a consumer could have saved had he chosen a different scheme. This approach has two potential caveats. First, the fact that certain pricing schemes were available at

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[1]Seminal papers on price discrimination and the importance of incentive compatibility constraints are Mussa and Rosen 1978 and Maskin and Riley 1984. More recent examples can be found in Armstrong 1996 and Hamilton and Slutsky 2004. A good textbook reference is Laffont and Martimort 2001.

[2]Examples of field studies include consumers' choices of health clubs contracts in DellaVigna and Malmendier 2006, of local telephone tariffs in Miravete 2003, of mobile phone plans in Grubb 2009, of tariffs for Internet access in Lambrecht, Seim, and Skiera 2007, of credit cards in Stango and Zinman 2009, and even of different-sized packages of light beer in Gu and Yang 2010.

the moment of choice does not imply that a consumer had them in the consideration set. Second, it is not clear at all whether a consumer correctly anticipated the consumption level. Moreover, in most cases the information on what the consumption level would have been with a different pricing scheme is not available even to a researcher. In line with the last issue, the existing literature attributes the observed errors in the choice of pricing schemes to consumers' imperfect demand forecasting skills and suggests that providing consumers with detailed feedback on past consumption would help solve the problem.

The advantage of the experimental approach to collecting data on consumers' choices of pricing schemes is that a researcher can have full information on what subjects know about their future demand and, hence, can evaluate the quality of their choices ex-ante. Observing ex-ante choice errors would imply that providing consumers with detailed feedback on their past consumption is insufficient in preventing sub-optimal choices. This addresses the second mentioned problem of field data. In addition, using available techniques to track how subjects acquire information on pricing schemes addresses the first mentioned problem of field data.[3] Particularly, a lab experiment makes it possible to see which of the available pricing schemes subjects consider.

In the experiment reported in this paper, subjects are explicitly told that their demand is a random variable with a discrete uniform distribution over a specified range. They need to choose from a set of four pricing schemes that imitate the structure of those from the motivating example in Fig. 2.1. Each of the first three schemes is the cheapest in one-third of all experimental tasks, and the fourth scheme is there to control for potential flat-rate and middle-alternative biases.[4] The expected demand is emphasized in the formulation of the experimental task, and the third pricing scheme offers the number of free minutes exactly equal to the expected demand. I refer to this scheme as the "matched" one. The lower bound of the demand range is never below the number of free minutes of the second scheme and never above the number of free minutes of the fourth scheme. This ensures that the "matched" scheme is the only one with a non-linear cost function over the possible demand range (even though all four pricing schemes have a non-linear cost function in general).

The main experimental finding is that with the overall error rate of 44.5%, subjects

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[3]In the experiment reported in this paper, I use a mouse tracking tool, while eye tracking is another available but more expensive technique.

[4]In case of flat-rate bias, subjects would be choosing the scheme with the number of free minutes that always covers their demand, that is the fourth scheme. The middle-alternative bias should not be profound when the number of available alternatives is even. If it is present, choosing each of the two middle alternatives should be equally likely.

choose the "matched" scheme when another scheme has a lower expected cost in 30.5% of all cases. Overall, subjects choose the "matched" scheme in 42.3% of the cases. One potential explanation is associated with the non-linear cost function over the possible demand range that makes this scheme different from all others. As also argued in Grubb 2009, when subjects do not take into account that their demand is equally likely to be at the lower bound, at the middle, and at the upper bound of the possible demand range but instead assume that it will be always at the middle, they tend to underestimate the expected cost of such a pricing scheme. Then they mistakenly believe that it is the cheapest when it is not. The difference between this paper and Grubb 2009 is that here the only reason for such consumer behavior is that they consciously choose to ignore the information provided to them, while in Grubb's field study it might be also the case that consumers are unaware of their possible demand range.

Another possible explanation for the observed pattern in subjects' choice errors is that their choices are affected by an appropriate framing of pricing schemes. This explanation is supported both by choice and information acquisition data. To collect information acquisition data, all parameters of pricing schemes are covered at the beginning of each experimental task. A subject needs to click on a particular parameter to see its value, and he can uncover only one parameter's value at a time. This feature of the experimental design allows me to see where subjects start their search for the best pricing scheme. Another important feature of the design is that in the first five sessions pricing schemes are labeled with the number of free minutes, as in the motivating example, such that subjects can infer where the "matched" scheme is, while in the last two sessions, pricing schemes are labeled neutrally.

The analysis of the information acquisition data reveals some kind of status quo bias: Subjects are more likely to choose a particular pricing scheme if they started the search process with this pricing scheme. At the same time, they are significantly less likely to start the search process with the "matched" pricing scheme when schemes are labeled neutrally. This observation again suggests that the subjects' choice of pricing schemes is affected by framing in a systematic manner.

The paper is organized as follows. In the next section, I formalize the consumer problem, list theoretical predictions, and discuss the underlying intuition. Then, I explain the experimental design and present the implementation details. I then discuss the main results and conclude.

2.2 Theoretical Predictions

2.2.1 Consumer Problem

For the purpose of this study, I assume that demand for a service is perfectly inelastic with respect to all prices and income. In this case, consumers are only concerned with satisfying their demand at the lowest cost and cannot adjust their consumption level to the chosen pricing scheme. This restriction excludes biases in demand estimation and dynamic inconsistency from the list of potential explanations for errors in the choice of pricing schemes.[5]

There is demand uncertainty in the consumer problem, though. Particularly, the demand level X is a random variable that follows a discrete uniform distribution with the support $[x_1, ..., x_\Theta]$.[6] This makes the consumer problem more cognitively demanding as consumers now have to compute the expected cost of each pricing scheme. Formally, the consumer problem is the following:

$$\min_{j=\{1,..,J\}} ES(X \,|j) = \frac{1}{\Theta} \sum_{\tau=1}^{\Theta} S(x_\tau \,|j), \qquad (2.1)$$

where $S(\bullet \,|j)$ is the cost function of pricing scheme j.[7] There are J pricing schemes available to consumers. Hence, the cognitive task that consumers face is to compute $S(x_\tau \,|j)$ Θ times, to take the average, and to repeat the procedure J times.[8] At the end, the scheme with the lowest expected cost should be chosen.

All pricing schemes have the same three-part structure. Consumers have to pay a fixed fee F_j at the beginning of each consumption period, then they get a bundle of I_j units that can be consumed within this period for no extra charge. If the realized demand is higher than I_j, consumers have to pay an extra-unit price P_j for every additional unit consumed. The structure of pricing schemes defines the functional form of $S(\bullet \,|j)$:

$$S(x_\tau \,|j) = F_j + P_j \max\{0, x_\tau - I_j\}. \qquad (2.2)$$

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[5]This also rules out empirical complications that arise when choices of a pricing scheme and of a consumption level are studied jointly, see e.g., Hanemann 1984.

[6]Upper case letters denote random variables; the corresponding lower case letters are their realizations.

[7]It is possible to impose the same consumer problem by introducing demand variation instead of demand uncertainty, e.g. the consumer would know his deterministic demand in Θ periods, such that in each period the demand would be equal to one of the values from the interval $[x_1, ..., x_\Theta]$. We use this approach in later studies.

[8]Of course, there are alternative computation routines to find the expected cost of each pricing scheme.

I refer to the pricing scheme that solves the consumer problem as the first-best scheme. Other pricing schemes are ranked based on their expected cost as the second-best, the third-best, and so on. Standard economic theory predicts that consumers always choose the first-best pricing scheme.

The ranking of pricing schemes relies on the assumption of a linear utility function from money, particularly risk neutrality. The assumption is supported by the fact that expenditure on the good under consideration is a small share of consumers' income. I further minimize possible effects of risk aversion with the experimental design. First, for the ease of interpretation, subjects are given a fixed ex-ante known per-period budget B and are paid the difference between the budget and the cost of the realized demand under the chosen pricing scheme. Practically, under the assumption of a linear utility function, they are incentivized to solve the following task:

$$\max_{j=\{1,..,J\}} B - ES\left(X \,|\, j\right), \tag{2.3}$$

which is equivalent to minimizing the expected cost $ES\left(X \,|\, j\right)$. The difficulty is that due to a non-linearity of the utility function, the solution to the following utility maximization problem might be different from the first-best scheme:

$$\max_{j=\{1,..,J\}} EU\left(B - S\left(X \,|\, j\right)\right) = \frac{1}{\Theta} \sum_{\tau=1}^{\Theta} U\left(B - S\left(x_\tau \,|\, j\right)\right), \tag{2.4}$$

where $S\left(X \,|\, j\right)$ is a random variable with up to Θ possible realizations.

To increase the chance of the utility maximization problem having the same solution as the cost minimization problem, T consumption periods under the chosen pricing scheme are introduced. In each consumption period, the demand is an independent realization of X. Not to deal with time discounting issues, subjects learn T realizations and the corresponding payoffs all at once, after they choose the pricing scheme.

Under the assumption of a linear utility function, the consumer problem becomes:

$$\max_{j=\{1,..,J\}} T * \left[B - ES\left(X \,|\, j\right)\right], \tag{2.5}$$

and its solution is still the first-best scheme. To see what happens with the utility maximization problem, note that $T * S\left(X \,|\, j\right)$ is a random variable itself with up to $\frac{(\Theta+T-1)!}{T!(\Theta-1)!}$ possible realizations. Some of the realizations might be identical for a certain

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cost function. In the original problem, each of $S(x_\tau | j)$ is equally likely to occur. After T consumption periods are introduced, realizations close to $T * ES(X | j)$ become more likely than extreme values $T * S(x_1 | j)$ and $T * S(x_\Theta | j)$. Even though the difference in utilities from extreme and average realizations under non-linear utility functions is different from this difference under the linear utility function, the probability of extreme realizations becomes very small when more periods are introduced. This potentially solves the problem with non-linear utility function.[9]

2.2.2 Predicted Choices

Finding the best pricing scheme in the consumer problem defined above is associated with computing the cost $S(x_\tau | j)$ Θ times, taking the average, repeating the procedure J times, and comparing the expected cost of all J schemes. This fully rational procedure leads to the following prediction:

Prediction R. *Consumers choose the pricing scheme with the lowest expected cost.*

The fully rational procedure is unlikely to represent what consumers actually do as computing $S(x_\tau | j)$ $\Theta * J$ times is a pretty boring task, and it is even more so when non-linear utility functions are allowed. I propose a number of calculation methods, or heuristics, that consumers might be using instead. The considered heuristics vary in their predictions what pricing scheme should be chosen from a particular set. The predictions are derived assuming that demand is a random variable X that follows a discrete uniform distribution with the support $[x_1, ..., x_\Theta]$, and this interval is symmetric around the mean. Using the experimental data, it is possible to say how good each decision rule is in predicting the subjects' choices.

There is a heuristic that gives a very good approximation of the expected cost under any pricing scheme. A consumer needs to compute his cost of the lowest, the mean, and the highest possible demand, and to take the average of these three values. Values of parameters used in the experiment are such that this heuristic always leads to the first-best choice of a pricing scheme. Using only choice data, it is impossible to distinguish empirically this heuristic from the fully rational procedure.

The next two heuristics allow for a precise computing of the expected cost under any pricing scheme whose cost function is linear at the possible demand range, but are misleading regarding the expected cost of the pricing scheme whose cost function is convex

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[9]For the reader who is not convinced that the experimental design sufficiently minimizes the effect of potentially non-linear utility functions, I discuss its predictions and performance in the Appendix.

at this range. With the first method, a consumer needs to compute only the cost of the expected demand. With the second one, he needs to compute the cost of the lowest and the highest demand and to take the average. With the first method, the consumer underestimates the expected cost of the pricing scheme whose cost function is convex at the possible demand range, while with the second one, he overestimates it.

I refer to the first method as the **"expected demand" heuristic**.[10] Instead of taking the average over $\{S(x_\tau | j)\}_{\tau=1}^{\Theta}$, a consumer takes the average over $\{x_\tau\}_{\tau=1}^{\Theta}$. Then he uses the expected demand $EX = \frac{1}{\Theta} \sum_{\tau=1}^{\Theta} x_\tau$ to evaluate the cost of each pricing scheme j:[11]

$$S(EX | j) = F_j + P_j \max\{0, EX - I_j\}, \tag{2.6}$$

and the consumer problem becomes:

$$\min_{j=\{1,...,J\}} S(EX | j). \tag{2.7}$$

The "expected demand" heuristic might naturally lead to a bias towards a pricing scheme whose cost function is convex at the possible demand range. I illustrate this for the case when the following restriction on a number of included units under different pricing schemes is imposed:

$$I_{j^*-1} \le x_1, \ I_{j^*} = \frac{x_1 + x_\Theta}{2}, \ I_{j^*+1} \ge x_\Theta, \tag{2.8}$$

where $j^* \le J-1$. The restriction implies that there is a pricing scheme j^* with the number of included units being equal to the expected demand. Also, the number of included units in the scheme $j^* - 1$ is never above the demand realization, while the number of included units in the scheme $j^* + 1$ is never below the demand realization. It means that there is only one pricing scheme whose cost function is convex at the considered demand range, while all others are linear at this range. The main consequence is that by using the "expected demand" heuristic, the consumer underestimates the expected cost of the scheme j^* and only of this scheme:[12]

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[10]It can be also named as the "average demand" or the "mean demand" heuristic.

[11]Note that under the assumption $[x_1, ..., x_\Theta]$ is symmetric around the mean, $EX = \frac{x_1 + x_\Theta}{2}$.

[12]This relies on the imposed assumption that the demand distribution is symmetric around the mean.

$$S\left(EX\left|j\right.\right) = ES\left(X\left|j\right.\right) \ \forall j \neq j^*, \tag{2.9}$$

$$S\left(EX\left|j^*\right.\right) < ES\left(X\left|j^*\right.\right). \tag{2.10}$$

If the difference between $ES\left(X\left|j^*\right.\right)$ and $S\left(EX\left|j^*\right.\right)$ is sufficiently large, a consumer who follows the "expected demand" heuristic might decide that scheme j^* is the first-best, while in fact it is not. This leads to the following prediction:

Prediction EDH. *Consumers who follow the "expected demand" heuristic, have a bias towards the scheme whose cost function is convex at the possible demand range.*

The EDH prediction follows from the fact that consumers choose the scheme whose cost function is convex at the possible demand range as long as this scheme has the lowest cost for the expected demand, which may happen even when the expected cost of this scheme is not the lowest.

The second calculation method that gives a wrong estimate of the expected cost of the pricing scheme whose cost function is convex at the possible demand range is the **"minimum-maximum" heuristic**. The heuristic works as follows: A consumer computes the minimum and the maximum possible cost and takes the average:

$$S_{MM}\left(X\left|j\right.\right) = \frac{1}{2}\left[S\left(x_1\left|j\right.\right) + S\left(x_\Theta\left|j\right.\right)\right] \tag{2.11}$$

$$= F_j + \frac{1}{2}P_j\left(\max\left\{0, x_1 - I_j\right\} + \max\left\{0, x_\Theta - I_j\right\}\right). \tag{2.12}$$

Under this heuristic, the cost of pricing scheme j^* and only this cost is over-estimated:

$$S_{MM}\left(X\left|j\right.\right) = ES\left(X\left|j\right.\right) \ \forall j \neq j^*, \tag{2.13}$$

$$S_{MM}\left(X\left|j^*\right.\right) > ES\left(X\left|j^*\right.\right). \tag{2.14}$$

If the difference between $ES\left(X\left|j^*\right.\right)$ and $S_{MM}\left(X\left|j^*\right.\right)$ is sufficiently large, a consumer who follows the "minimum-maximum" heuristic might decide that scheme j^* is not the first-best, while in fact it is. This leads to the following prediction:

Prediction MMH. *Consumers who follow the "minimum-maximum" heuristic are averse towards the scheme whose cost function is convex at the possible demand range.*

The MMH prediction follows from the fact that consumers do not choose a scheme whose cost function is convex at the possible demand range as long as it does not have the lowest average cost for the minimum and maximum demand, which may be the case even when the expected cost of this scheme is the lowest.

The heuristics presented above predict correctly which scheme is the first-best in a wide range of cases. This makes their usage efficient, or ecologically rational. The next heuristic leads to substantial deviations from the first-best choice, but it requires no computations. I call it the **"match" heuristic**. This heuristic is to choose the pricing scheme with the number of included units equal to the expected demand, unless it is apparently worse than another scheme. The name of this heuristic comes from treating the equality between the expected demand and the number of included units as a "match". In the consumer problem considered here, the scheme that matches the demand is j^*.

The question is what makes the matched scheme apparently worse than another scheme. I only consider the most obvious case — when the fixed fee of a scheme with a larger number of included units is lower than the fixed fee of the matched scheme:

$$F_{j^*+1} < F_{j^*}. \tag{2.15}$$

In this case, the consumer chooses the scheme $j^* + 1$. Otherwise, he chooses the matched scheme. The prediction of the "match" heuristic is the following:

Prediction Match. *Consumers who follow the "match" heuristic have a strong bias towards the scheme whose cost function is convex at the possible demand range.*

The Match prediction follows from the fact that in the considered problem, the consumers' expected demand is always equal to the number of included units of the scheme whose cost function is convex over the possible demand range. In most cases, the fixed fee of this scheme is lower than the fixed fee of schemes with a larger number of included units. As consumers do not even compute their expected costs, they choose the scheme whose cost function is convex at the demand range simply because it matches their demand the best.

While the "expected demand" and the "minimum-maximum" heuristics can be treated as alternative calculation methods, the "match" heuristic is more than that. It suggests how the starting point of a search process is determined. Within search models, both rational and boundedly rational, a bias towards the alternative that is considered earlier in the search process is a general prediction. In the next section, I discuss other implications

of treating the choice of a pricing scheme as a search.

2.2.3 Predicted Search Patterns

Even though all pricing schemes available to consumers are located at one "store", consumers do not immediately observe their values. To infer these values, consumers need to compute how much it would cost them to satisfy their demand with each pricing scheme. Such computations can be treated as search. The difference from standard search models is that consumers do not necessarily search sequentially when they need to choose a pricing scheme, i.e. instead of doing a one-by-one evaluation, they might be doing a parameter-by-parameter comparison. In Chapter 1 of this dissertation, the focus is on the implications of this important difference. Here, predictions of standard alternative-based search models applied to the choice of pricing schemes are derived and tested.

The alternative-based search process applied to the choice of pricing schemes can be described as follows. A consumer starts with a pricing scheme j^0 and computes how much it would cost him to satisfy his demand with this scheme. He can either do the full computation and learn $ES\left(X\left|j^0\right.\right)$, apply the "expected demand" heuristic and learn $S\left(EX\left|j^0\right.\right)$, or apply the "minimum-maximum" heuristic and learn $S_{MM}\left(X\left|j\right.\right)$. Given the restrictions used in the experiment, the result is different only for the case when $j^0 = j^*$. The next step would be different within the optimization-under-constraints (Stigler 1961) and the satisficing (Simon 1955) approaches.

Within the optimization-under-constraints approach, the consumer needs to evaluate the benefit of a further search and to compare it with the cost. When the consumer deals with pricing schemes with immediately observable parameters, he can evaluate the benefit of a further search using these parameters. Particularly, he can easily see the difference between fixed fees and use it as an indicator of the benefit of a further search. The steps would be the following:

1. Compare the difference between F_{j^0} and F_{j^1} with the search cost c_1.

1.a. If the difference is larger than the search cost, compute how much it would cost to satisfy demand under the scheme j^1. Else, go to step 2, keeping the scheme j^0 as the current choice, j^c.

1.b. Depending on the computation method used, compare $ES\left(X\left|j^0\right.\right)$ and $ES\left(X\left|j^1\right.\right)$, $S\left(EX\left|j^0\right.\right)$ and $S\left(EX\left|j^1\right.\right)$, or $S_{MM}\left(X\left|j^0\right.\right)$ and $S_{MM}\left(X\left|j^1\right.\right)$. Keep the "winner" scheme as the current choice, j^c.

2. Compare the difference between F_{j^c} and F_{j^2} with the search cost c_2.

...

The process continues until all pricing schemes are considered, that is, their fixed fees are compared to that of scheme j^c. The scheme that represents the current choice at the very end of the process, is chosen. Notice that the search cost is allowed to be different at every step of the search process. It is natural to assume that the search cost would be correlated with parameters of the scheme that is considered. That is, the search cost is likely to be higher when more arithmetic operations are required to compute the expected cost under the considered scheme.

In principle, any choice of a pricing scheme can be justified by a particular sequence of considering schemes in a combination with a particular level of search costs. A bias towards schemes considered early in the search process should be expected. To make a clear comparative static prediction, one needs to assume that consumers always process schemes in the same order, and their search costs for schemes with the same number of included units do not change over time. Based on this assumption, the comparative static prediction is the following.

Prediction OUC. *Assume that consumers use the difference in fixed fees to evaluate the benefit of a further search. Other things equal, when the difference in fixed fees of available schemes is lower, consumers are more likely to choose the scheme with which they started the search process.*

Next, consider the satisficing approach. Applied to the choice of pricing schemes, this implies that the consumer compares the difference between his budget B and $ES\left(X\left|j^0\right.\right)$ if he uses the "expected demand" heuristic, and $S_{MM}\left(X\left|j^0\right.\right)$ if he uses the "minimum-maximum" heuristic, with his aspiration level A. The aspiration level does not have to be the same every time when the consumer faces the problem of choosing a pricing scheme. It might be adjusted to the previously achieved payoff and even to the currently observed difference between B and the perceived cost of j^0.

Again, a bias towards schemes considered early in the search process should be expected. A consumer's consistency in the order of search and in the aspiration levels should be assumed to generate the comparative static prediction:

Prediction SAT. *Assume that consumers follow the satisficing approach. Other things equal, when the difference between the budget and the perceived cost of the scheme that they consider first is higher, consumers are more likely to choose this scheme.*

In the standard search models, the order in which alternatives are considered is ran-

dom as there are no observables that can be used to structure the search process. The contribution of this study is a proposal to treat labels of pricing schemes as observables that can be used by consumers to structure the search process. That is, if subjects can construct a "match" between the immediately observable characteristics of pricing schemes and their demand, they will start a search with the "matched" scheme. The corresponding comparative static prediction is the following:

Prediction Label. *When the number of included units is not reflected in the name of pricing schemes, consumers are less likely to consider the "matched" scheme first.*

As both search models predict, we should expect a bias towards the scheme that subjects consider at the first step of their search process. This is reflected in the following prediction on the correlation between the order of a search and the resulting choice of pricing schemes:

Prediction Search. *Consumers are more likely to choose a particular pricing scheme when they start the search process with this scheme.*

Notice, however, that there is endogeneity involved here. Consumers might be a priori more interested in particular schemes and hence consider them first, and then, as both search models predict, the scheme considered first is more likely to be chosen simply due to the presence of search costs.

2.3 Experiment

2.3.1 Design

The experiment consists of 27 tasks, which are identical (but not exactly the same) for all subjects, and 3 tasks are added in Session 3 and later ones to control for the subjects' risk attitude. The experiment is designed such that the subjects' incentives to maximize their expected payoff are equivalent to their incentives to choose a pricing scheme with the lowest expected cost, $ES(X|j)$. In each of the 3 tasks added later, two pricing schemes have the same expected cost, being the first-best. One scheme has a higher number of included units and, hence, a lower variation in possible cost. A risk-averse subject prefers such a pricing scheme even when the coefficient of risk aversion is close to 0.

Every task consists of a pricing-scheme choice and a consumption stage where no action is required. In task t, a subject i has to select one pricing scheme out of four offered

to him, $J = 4$ (see Fig. 2.4).[13] He knows that his choice will determine his consumption cost in six periods, $K = 6$. Demand in period k, X_{tik}, is an independent random variable with a discrete uniform distribution over the interval $[EX - 5\varepsilon_{ti}, EX + 5\varepsilon_{ti}]$, where $\varepsilon_{ti} = \{1, 2\}$ defines the uncertainty level, low or high.[14] The uncertainty level is fixed for all consumption periods within a particular task for a particular subject, but it varies across subjects and tasks. The way how uncertainty is introduced into the experimental design serves two purposes. First, demand uncertainty in one consumption period makes the pricing-scheme choice cognitively demanding. Second, the presence of six periods minimizes the risk of having a too low or too high demand realization, and hence minimizes possible effects of the subjects' risk attitude.

The consumption stage gives subjects feedback on the chosen pricing scheme but does not reveal whether it is the best choice. At the consumption stage, a subject observes the realized demand for every consumption period k, x_{tik}, his earnings from the corresponding period, and the total earnings from the task (see Fig. 2.5). He is not aware of minimum and maximum possible earnings in each task. The only action required from a subject is to move to the next task by clicking on the only available button on the computer screen.

For every consumption period k in a task t, a subject i has a budget B_{ti}. This per-period budget is the same for all periods. It varies across tasks and subjects facing different uncertainty levels. Earnings from a particular period are equal to the difference between the budget B_{ti} and the realized expenditure, conditional on the prior pricing-scheme choice j, $S(x_{tik}|j)$. The purpose of introducing such a budget is to present a clear and direct incentive scheme to subjects: They get whatever they earn.

At the stage of pricing-scheme choice, a subject knows the rules of the game, the values of EX, ε_{ti}, and B_{ti}. The rules of the game are explained in the instructions. The experimenter reads them at the beginning of the experiment, and they stay open in a separate window on the computer screen during the experiment.[15] The values of EX, ε_{ti}, and B_{ti} are explicitly shown on the screen at the stage of the pricing-scheme choice (Fig. 2.4). The subject only lacks the information on the demand realization. He learns

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[13]Three pricing schemes are needed to implement the conditions on the number of included units introduced in Section 2.2.2. The fourth scheme is needed to control for a possible "golden middle" bias.

[14]Note that the support interval consists of 11 elements for every level of uncertainty. When $\varepsilon_{ti} = 1$, the set is $\{45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55\}$ units. When $\varepsilon_{ti} = 2$, the set is $\{40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60\}$ units. In both cases, the same number of arithmetic operations is needed for computing the expected cost. So, the complexity level is not affected.

[15]The instructions from the first two sessions are given in the Appendix. They differ fom the instructions for later sessions by the number of experimental tasks, the expected earnings expressed in ECU, and the transfer rate from ECU to CZK.

it together with the realized earnings after he makes a pricing-scheme choice (Fig. 2.5). The subject cannot revise the pricing-scheme choice at the consumption stage.

A subject can learn the parameters of the pricing schemes, $\{F_{tij}, I_{tij}, P_{tij}\}_{j=1,\ldots,4}$, at no monetary cost by clicking on the specified cells of the table and "uncovering" them. He can observe only one parameter at a time. The Mouselab Web tool records the sequence of information acquisition together with the time span for which every parameter is displayed on the screen.[16] Subjects can take notes during the experiment. They can, for instance, copy all the parameters they are interested in on a sheet of paper. The notes are collected after the experiment, but subjects do not know during the experiment that this will be done. At the stage of the pricing-scheme choice, a simple calculator is available for making necessary computations. Data on performed calculations are also collected.

Prior to the experiment, there are two practice tasks to get subjects familiarized with the structure of the experiment. They do not get earnings from the practice tasks. Subjects work through the experiment at their own pace. After they complete all tasks, the information on total earnings, which are the sum of earnings in all tasks, appears on the screen (Fig. 2.6).[17] In the experimental tasks, everything is measured in experimental currency units (ECU). The final earnings are transferred to Czech crowns (CZK) at the rate 1 ECU to 0.05/0.045 CZK depending on the number of tasks in the session.[18]

The values of parameters used in the experiment are such that the expected earnings from scheme j in task t are the same for all subjects. At the same time, subjects are assigned to different uncertainty treatments as shown in Table 2.1. In Session 1, $\varepsilon_{ti} = 1$ for all t and i (treatment 1). In Session 2, $\varepsilon_{ti} = 2$ for all t and i (treatment 6). In Sessions 3-7, subjects are randomly assigned into one of four treatments (treatments 2-5), where they get tasks with both $\varepsilon_{ti} = 1$ and $\varepsilon_{ti} = 2$. This enables estimating the effect of uncertainty using within- and between-subject variations.

The bundles of included units are the same for all subjects in all tasks in all sessions: $I_{ti1} = I_1 = 30$, $I_{ti2} = I_2 = 40$, $I_{ti3} = I_3 = 50$, and $I_{ti4} = I_4 = 60$ for all t and i. I refer to the pricing schemes used in the experiment as "Included 30", "Included 40", "Included 50", and "Included 60". In Sessions 1-5, the schemes are named this way in the table used to present a decision task to subjects. In Sessions 6-7, the names are changed to more neutral "Plan A", "Plan B", "Plan C", and "Plan D". All other parameters of the

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[16]More information about the Mouselab Web tool can be found on its page: http://mouselabweb.org/.

[17]The sum of earnings in all tasks rather than earnings from a randomly chosen task is paid not to reveal to subjects that the maximum expected earnings in some tasks are twice as high as in others.

[18]At the time of the experiment, 1 Czech crown was approximately 0.05 U.S. dollars.

Table 2.1: Variation in uncertainty level across treatments and tasks: The demand range is {45,46,...,50,...,54,55} in the case of low uncertainty and {40,42,...,50,...,58,60} in the case of high uncertainty. The parameters of the pricing schemes are adjusted to have the same expected earnings in a given task in all treatments.

task	T1	T2	T3	T4	T5	T6	task	T1	T2	T3	T4	T5	T6
1	L	H	L	H	L	H	16	L	H	L	L	H	H
2	L	L	H	L	H	H	17	-	H	L	L	H	-
3	L	H	L	H	L	H	18	L	L	H	L	H	H
4	L	H	L	L	H	H	19	L	H	L	L	H	H
5	L	H	L	L	H	H	20	L	L	H	H	L	H
6	L	L	H	H	L	H	21	L	H	L	H	L	H
7	-	H	L	L	H	-	22	L	H	L	L	H	H
8	L	H	L	H	L	H	23	L	L	H	L	H	H
9	L	L	H	L	H	H	24	L	H	L	L	H	H
10	L	L	H	H	L	H	25	L	H	L	H	L	H
11	L	L	H	H	L	H	26	L	L	H	H	L	H
12	L	L	H	H	L	H	27	-	H	L	L	H	-
13	L	L	H	L	H	H	28	L	H	L	H	L	H
14	L	L	H	H	L	H	29	L	L	H	H	L	H
15	L	L	H	L	H	H	30	L	L	H	H	L	H

pricing schemes are the same across sessions, and they are covered using the Mouselab table. Hence, the only difference between Sessions 1-5 and 6-7 is in the former ones, subjects immediately observe the number of included units under each scheme. The expected demand is fixed for the entire experiment, and it is equal to the number of included units under one of the schemes, $EX = 50$.

The extra unit prices vary across tasks, but they are the same for all subjects within the same task: $P_{tij} = P_{tj}$ for all i. To keep the expected earnings at the same level for different uncertainty treatments, the fixed fees are adjusted across tasks and also across treatments.[19]

To see whether subjects choose other than the first-best pricing schemes and to test the validity of potential explanations, the following variations across the 30 experimental tasks are imposed (see also Table 2.5). Among these 30 tasks, there are 10 tasks where the scheme "Include 30" is the first best, 10 tasks where it is the scheme "Included 40", and 10 tasks where it is the scheme "Included 50". The tasks vary in the highest expected level of per-period earnings, which is either 100 ECU (high-stake tasks) or 50 ECU (low-stake tasks). The difference in earnings between the first-best and the second-best schemes varies between 0 ECU and 30 ECU, and the difference in earnings between the second-best and the third-best schemes is either 0 ECU or 10 ECU. The generated cost of a choice

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[19]Variations in fixed fees are only needed to equalize the expected earnings under the "Included 50" scheme in tasks with different uncertainty levels.

error is between 10 ECU and 40 ECU. Due to the imposed variations in the parameters of the pricing schemes and the uncertainty level, there is a variation in the predictions of the decision rules introduced in Section 2.2.2. This variation is reflected in Table 2.5.

Table 2.2: Choice predictions under alternative computation methods in each task depending on the uncertainty level: Those in bold do not maximize expected earnings.

task	max payoff	cost of error 2nd-best	3rd-best	$ES(X)$	$S(EX)$ L	H	$S_{MM}(X)$ L	H	match
1	100	10	20	I50	I50	I50	I50	**I40**	I50
2	50	5	10	I50	I50	I50	**I40**	**I40**	I50
3	100	10	20	I40	I40	**I50**	I40	I40	**I50**
4	100	20	30	I50	I50	I50	I50	I50	I50
5	100	20	30	I30	I30	I30	I30	I30	**I50**
6	100	30	40	I50	I50	I50	I50	I50	I50
7	100	0	20	I50,I60	**I50**	**I50**	**I60**	**I60**	I50
8	50	10	15	I40	**I50**	**I50**	I40	I40	I50
9	50	5	10	I30	**I50**	**I50**	I30	I30	I50
10	100	30	40	I40	I40	I40	I40	I40	**I50**
11	100	30	40	I30	I30	I30	I30	I30	**I50**
12	100	20	20	I30	I30	**I50**	I30	I30	**I50**
13	50	20	25	I40	I40	I40	I40	I40	**I50**
14	50	15	20	I40	I40	I40	I40	I40	**I50**
15	50	20	25	I30	I30	I30	I30	I30	**I50**
16	50	10	20	I30	I30	I30	I30	I30	**I50**
17	100	0	20	I30,I60	I30,I60	I30,I60	I30,I60	I30,I60	**I60**
18	50	20	25	I50	I50	I50	I50	I50	I50
19	50	10	20	I50	I50	I50	I50	**I40**	I50
20	100	20	20	I50	I50	I50	I50	I50	I50
21	50	10	15	I30	I30	**I50**	I30	I30	**I50**
22	100	20	30	I40	I40	I40	I40	I40	**I50**
23	50	5	10	I40	**I50**	**I50**	I40	I40	**I50**
24	50	10	20	I40	I40	**I50**	I40	I40	**I50**
25	100	10	20	I30	I30	**I50**	I30	I30	**I50**
26	50	15	20	I30	I30	**I50**	I30	I30	**I50**
27	100	0	20	I40,I60	I40,I60	I40,I60	I40,I60	I40,I60	**I60**
28	50	10	15	I50	I50	I50	I50	I50	I50
29	50	15	20	I50	I50	I50	I50	I50	I50
30	100	20	20	I40	I40	I40	I40	I40	**I50**

2.3.2 Implementation

Data from the web-based experiment were collected in seven sessions. Except for Session 2, when I conducted the experiment with CERGE-EI preparatory semester students, subjects were undergraduate students from universities in Prague who registered in the database for experiments.[20] Sessions 1-5 were conducted in July-August 2010, at the

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[20]Students can register in the database through the web-page: http://www.experimenty.eu/public/.

CERGE-EI computer lab, which has 18 machines. Sessions 6-7 were conducted in March 2011, in the Laboratory of Experimental Economics in Prague.[21] A total of 106 participants showed up. Available individual characteristics are summarized in Table 2.3.

The average time spent on the experiment was 47 minutes, and the average earnings were 540 CZK. The average earnings were 529 CZK for those subjects who spent less than the average time on the experiment and 551 CZK for those who spent more than the average time on the experiment. The difference is small but statistically significant.

Table 2.3: A summary of individual characteristics, missing observations are present.

Individual characteristic	S1	S2	S3	S4	S5	S6	S7	**Total**
Gender:								
- male	10	8	16	8	11	10	16	**79**
- female	2	4	0	6	6	7	2	**27**
Field of study:								
- economics	3	4	8	9	13	11	17	**65**
- other	9	7	8	5	3	6	1	**32**
Year of admission:								
- before 2006	3	-	6	7	2	1	1	**20**
- 2006-2007	3	-	4	4	9	5	8	**33**
- after 2007	6	-	5	1	6	11	8	**37**
Year of birth:								
- before 1986	4	3	8	7	2	2	1	**27**
- 1986-1987	4	3	3	3	6	5	11	**35**
- after 1987	4	1	4	3	8	9	6	**35**
Mobile operator:								
- Vodafone	5	-	9	6	7	5	12	**44**
- Telefonica O2	3	-	5	4	7	9	1	**19**
- T-mobile	3	-	2	3	3	3	5	**19**
Number of subjects:	12	12	16	14	17	17	18	**106**
Avg. earnings (CZK):	537	509	551	542	554	525	549	**540**
Avg. time (minutes)	27	58	45	47	45	55	51	**47**

2.4 Results

2.4.1 Predictive Power of Alternative Choice Rules

The observed choices in 30 experimental tasks are summarized in Table 2.4.

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[21]The web-page of the lab is http://www.vse-lee.cz.

Table 2.4: Observed choices depending on the uncertainty level, low (L) or high (H): Those in bold maximize expected earnings.

	I30		I40		I50		I60			I30		I40		I50		I60	
	L	H	L	H	L	H	L	H		L	H	L	H	L	H	L	H
1	.08	.1	.17	.14	**.71**	**.69**	.04	.06	16	**.35**	**.46**	.07	.12	.44	.35	.13	.08
2	.1	.13	.25	.17	**.53**	**.58**	.12	.13	17	**.19**	**.2**	.17	.1	.21	.08	**.43**	**.63**
3	.09	.06	**.51**	**.32**	.3	.38	.9	.25	18	.09	.09	.13	.09	.7	.74	.08	.08
4	.11	.1	.11	.14	**.67**	**.71**	.11	.06	19	.15	.02	.2	.1	**.54**	**.85**	.11	.04
5	**.41**	**.5**	.13	.06	.26	.33	.2	.12	20	.14	.11	.08	.06	**.75**	**.65**	.04	.19
6	.08	.07	.06	.07	**.79**	**.74**	.08	.11	21	**.45**	**.28**	.11	.09	.30	.47	.13	.15
7	.1	.05	.05	.13	**.48**	**.23**	.38	**.6**	22	.09	.04	**.59**	**.62**	.26	.35	.06	-
8	.13	.09	**.4**	**.36**	.28	.34	.19	.21	23	.04	.08	**.47**	**.42**	.42	.47	.08	.04
9	**.21**	**.11**	.21	.17	.45	.55	.13	.17	24	.13	.1	**.48**	**.4**	.33	.4	.06	.1
10	.02	.09	**.77**	**.56**	.12	.22	.1	.13	25	**.43**	**.36**	.09	.04	.38	.42	.1	.19
11	**.46**	**.35**	.1	.17	.37	.46	.08	.02	26	**.56**	**.33**	.12	.17	.25	.39	.08	.11
12	**.52**	**.32**	.1	.11	.17	.35	.21	.22	27	.14	.05	**.33**	**.25**	.1	.03	**.43**	**.68**
13	.06	.08	**.62**	**.42**	.19	.36	.13	.15	28	.08	.11	.19	.17	**.68**	**.6**	.06	.11
14	.06	.09	**.69**	**.46**	.12	.3	.14	.15	29	.04	.09	.12	.13	**.83**	**.7**	.02	.07
15	**.47**	**.43**	.15	.09	.25	.32	.13	.15	30	.02	.09	**.79**	**.57**	.04	.2	.15	.13

A pricing scheme is defined as the first-best if it is associated with the highest expected earnings. Under the assumption of risk neutrality, the standard optimization theory predicts that subjects always choose first-best schemes (Prediction R in Section 2.2.2). The experimental data clearly reject this hypothesis.

Result 1. *Subjects' choices maximize their expected earnings in 55.5% of the cases.*

Moreover, deviations from the first-best are not random, as Fig. 2.2 illustrates.[22] Such deviations are least common when the first-best scheme is "Included 50", the only one with a convex cost function over the possible demand range, and most of the deviations are towards this scheme. This informally suggests the idea that the "expected demand" heuristic and the "match" heuristic are popular decision rules among subjects as only they predict a bias towards the pricing scheme with a convex cost function over the demand range. The following analysis supports this idea more formally.

First, the overall proportions of choices predicted by different decision rules are compared. The proportions of predicted choices are presented in Table 2.5, and the comparison is done based on the paired t-test. Note that given the number of subjects that participated in each uncertainty treatment, the "expected demand" heuristic predicts a bias towards the scheme "Included 50" in 21% of the cases (Prediction EDH in Section 2.2.2), and the "minimum-maximum" heuristic predicts aversion towards the scheme "Included 50" in 6% of all the cases (Prediction MMH in Section 2.2.2).

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[22]Formal marginal homogeneity tests are given in Table 2.8.

Figure 2.2: Subjects' choices of pricing schemes depending on which scheme is first-best.
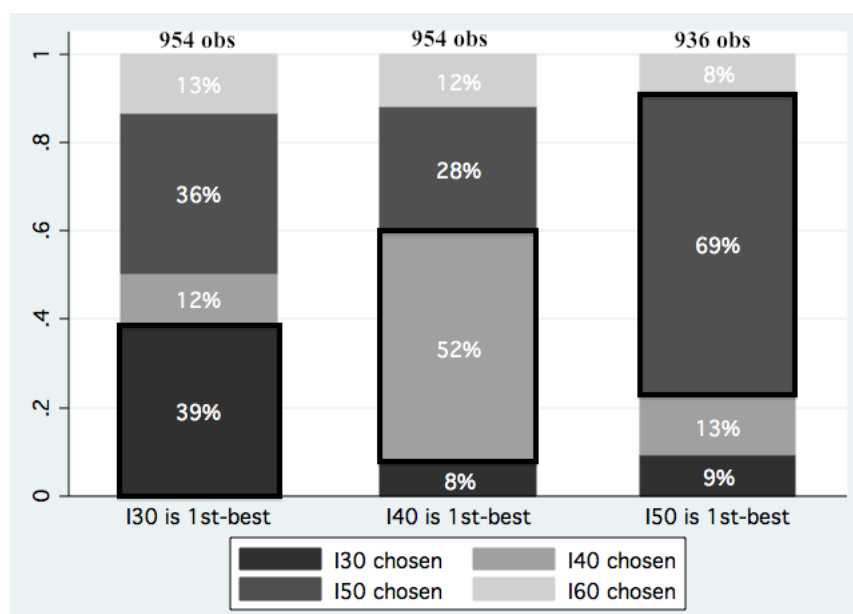
Result 2: *Subjects' choices are predicted by the "expected demand" heuristic in 59.9% of the cases. This is significantly higher than the proportion of choices predicted by the maximization of expected earnings (t=6.91).*

Result 3: *Subjects' choices are predicted by the "minimum-maximum" heuristic in 51.7% of the cases. This is significantly lower than the proportion of choices predicted by the maximization of expected earnings (t=-8.54).*

Table 2.5: The predictive power of the considered decision rules

Decision rule	Correct predictions	Uniquely the best predictor	
		# subjects	correct predictions
Maximize expected payoff*	.555 (.232)	12	.788 (.2)
"Expected demand" heuristic	.599 (.219)	36	.681 (.213)
"Minimum-maximum" heuristic	.517 (.224)	6	.517 (.246)
"Match" heuristic	.445 (.165)	27	.571 (.155)

(*)This rule is equivalent to "minimize average cost for min, max, and expected demand".

The above results allow a discrimination between the "expected demand" and the "minimum-maximum" heuristics: while the first one helps to explain more choices than the standard choice theory, the second does worse than the standard choice theory.

The raw data on choices across experimental tasks presented in Table 2.4 reveal a large variation across subjects and tasks. In those tasks where different decision rules predict the same choice, most of the subjects make this choice. In those tasks where different decision rules predict different choices, the corresponding schemes are more or

less equally popular. This observation suggests that different subjects might be using different decision rules. Table 2.5 supports this idea, where the total number of subjects for whom a given decision rule predicts the largest share of choices, and no other decision rule from those considered predicts the same share of choices, is presented. The most notable result is a relatively good performance of the simple "match" heuristic that predicts that "Included 50" should be chosen unless "Included 60" has a lower fixed fee (Prediction Match in Section 2.2.2).

Result 4: *The "match" heuristic is the best predictor for 25.5% of the subjects, excluding those for whom a different decision rule predicts the same share of choices.*

Admittedly, the decision rules considered in this paper are ad hoc and the above results only say that some of them give better predictions than others. To understand whether subjects indeed follow these rules, a different type of data should be used. In Chapter 1 of this dissertation, the process data have been used. Here, this type of data would not be as illustrative as subjects were allowed to take notes and many of them simply copied the parameters of the offered pricing schemes on the paper. This is a negative side of letting them take notes. The positive side is that these notes are available for an analysis and in some cases, they are very illustrative (see Fig. 2.7). Table 2.6 summarizes what decision rules were followed by the subjects as it can be inferred from their notes.

Assuming that not taking notes or taking notes without any computations can be treated as an indicator that a subject uses the "match" heuristic, the correlation coefficient between the variable that measures which decision rule is the best predictor and the variable that measures which decision rule is likely to be used based on the notes is .522. When the first variable is regressed on the second and the standard errors are clustered at the subject level, the coefficient is statistically significant and equal to .551.

2.4.2 Choice of Pricing Schemes as a Search. The Role of Labels

In Section 2.2.3, the choice of pricing schemes is treated as an alternative-based search process. Subjects are assumed to evaluate the cost of each pricing scheme until they find the one which is sufficiently good. Under this assumption, they are more likely to choose a particular scheme if they consider it at the beginning of the search process (Prediction Search in Section 2.2.3). A joint analysis of process and choice data from the experiment supports this prediction (see Table 2.9 and Fig. 2.3).

Table 2.6: Computations made by the subjects on provided paper.

Computations	# subjects	The best predictor is:			
		FB	EDH	MMH	Match
cost of min, max, and expected demand	5	3	-	-	-
cost of expected demand	16	2	11	-	-
cost of min and max demand	7	-	2	1	2
cost of min or max demand	6	1	1	1	2
demand-neutral*	16	2	2	3	7
not identifiable	21	1	11	-	4
no computations	8	1	3	-	3
no notes	27	2	6	1	9
Total	106	12	36	6	27

(*)This includes computations like dividing a fixed fee by the number of included units, difference between fixed fees, etc.

Result 5: *Subjects are most likely to choose a particular scheme when they open its parameter with the first mouse click in the experimental task.*

As it follows from Fig. 2.3, subjects are most likely to choose the scheme "Included 50" no matter which scheme they open with the first mouse click, but the probability of choosing it is the highest (53%) when it is considered first. It is also high (46%) when subjects choose a scheme without opening any pricing scheme.

This observation may imply is that subjects endogenously pick their default option, which they are more likely to choose at the end. The "match" heuristic suggests that when subjects immediately observe the number of included units in each scheme, this induces them to pick the scheme with the number of included units equal to the expected demand as the default option (Prediction Label in Section 2.2.3). To test whether this is the case, the first mouse clicks in the sessions where schemes are labeled as "Included 30" to "Included 60" are compared with those in the sessions where schemes are labeled neutrally.

Result 6: *The probability of opening "Included 50" with the first mouse click is 16.5% (s.e. .0082) when schemes are labeled with the number of included units and only 7.8% (s.e. .0084) when they are not. The difference is statistically significant.*

One would expect that once subjects are more likely to choose the pricing scheme that they open with the first mouse click, and they are more likely to open the "matched" scheme with the first mouse click when labels of pricing schemes reflect the number of included units, then subjects would be more likely to choose the "matched" scheme in the sessions where schemes are labeled as "Included 30" to "Included 60". However, this

Figure 2.3: The subjects' choices of pricing schemes depending on the scheme that has been opened first (percentage of corresponding choices).
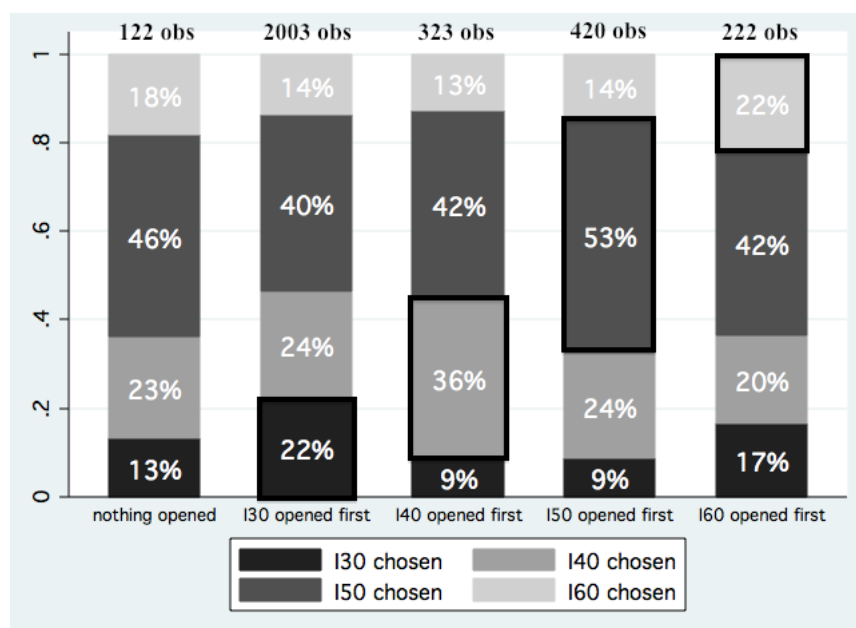
is not what happens in the experiment. What happens is that subjects become less likely to choose the scheme "Included 30" and more likely to choose the scheme "Included 60".

Result 7: *Other things equal, the probability of choosing "Included 30" decreases and the probability of choosing "Included 60" increases when labels of pricing schemes do not contain any information about the parameters of pricing schemes. The probabilities of choosing other schemes are not affected significantly.*

My interpretation of this result is that putting the number of included units into the labels of pricing schemes reduces the subjects' ambiguity regarding the value of pricing schemes. Their tendency to choose a safe option, "Included 60", is lower when they have a better idea about the value of offered pricing schemes. Otherwise, it is easy for them to discover the number of included units under each pricing scheme, to form a "match", and to proceed in evaluating pricing schemes in the corresponding order.

When the choice of a pricing scheme is treated as a search process, there are clear comparative static predictions how the variables that measure the satisfaction level and the expected benefits of further search affect the probability of choosing a particular scheme (OUC and SAT in Section 2.2.3). To measure the first variable, the difference between the expected earnings of the scheme that is opened with the first mouse click is used. To measure the second variable, the difference in the fixed fees between the schemes is used. As the first-best scheme is controlled for, none of these variables should

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Table 2.7: The probability of choosing a particular pricing scheme

Variable	Meaning
MALE	=1 if subject is male, =0 if subject is female
ECON	=1 if subject has an economic background, =0 otherwise
FIRST-BEST	=1 if the corresponding scheme is first-best, =0 otherwise
F60 - F50	difference in fixed fees between "Included 60" and "Included 50"
F50 - F40	difference in fixed fees between "Included 50" and "Included 40"
F40 - F30	difference in fixed fees between "Included 40" and "Included 30"
SAT30	expected earnings of "Included 30" if it was considered first
SAT40	expected earnings of "Included 40" if it was considered first
SAT50	expected earnings of "Included 50" if it was considered first
SAT60	expected earnings of "Included 60" if it was considered first
NO LABEL	=1 if number of included units is not in the label, =0 otherwise

	Subjects' choice			
	Included 30	Included 40	Included 50	Included 60
MALE	-.0295 (.0369)	.0278 (.0258)	.0353 (.0487)	-.042 (.008)
ECON	-.0305 (.028)	-.0005 (.0242)	.0705 (.0375)*	-.0447 (.0243)**
FIRST-BEST	.1578 (.0353)***	.1383 (.0428)***	.1045 (.0375)***	.3745 (.0603)***
F60-F50	.0003 (.0007)	.0003 (.0007)	.008 (.0012)***	-.0006 (.0008)
F50-F40	.0006 (.0004)	.0055 (.0008)***	-.0064 (.001)***	.001 (.0005)*
F40-F30	.0026 (.0005)***	-.0022 (.0007)***	-.0007 (.0006)	.0008 (.0003)**
SAT30	.0009 (.0003)***	-.0007 (.0003)**	-.0023 (.0004)***	.0002 (.0003)
SAT40	-.0013 (.0005)**	.0005 (.0004)	-.0012 (.0006)*	.0001 (.0004)
SAT50	-.0014 (.0005)***	-.0009 (.0005)**	-.00002 (.0005)	.0004 (.0004)
SAT60	.0008 (.0008)	-.0017 (.0007)**	-.0023 (.001)**	.0008 (.0006)
NO LABEL	-.0398 (.0262)	-.0134 (.0216)	-.0066 (.0391)	.0616 (.0238)***
pseudo R2	.165	.1678	.1328	.1074
# observations	3,033	3,033	3,033	3,033

* - 10% significance level, ** - 5% significance level, *** - 1% significance level

Entries are the marginal effects from the corresponding probit models.
Standard errors clustered at subject level are in parentheses.

affect the probability of choosing a particular scheme by fully rational consumers. The estimation results reported in Table 2.7 suggest that this is not the case.

Result 8: *Other things equal, the probability of choosing scheme $j+1$ decreases, and the probability of choosing scheme j increases with the difference in the fixed fees between the schemes $j+1$ and j.*

The result implies that subjects correctly respond to the expected benefits of a further search, measured with the differences between fixed fees. Other explanations for the observed patterns are also possible. The above result supports the optimization-under-constraints approach. The next result supports the satisficing approach (see Table 2.7).

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Result 9: *Other things equal, the probability of choosing a pricing scheme j that is not opened at the first mouse click decreases with the expected earnings of the scheme opened at the first mouse click.*

Given that the above results are based on the aggregate data, it is impossible to say whether both search models are supported due to a combined stopping rule used by a typical subject or due to different subjects using different stopping rules. However, it still suggests that the choice of a pricing scheme can be treated as a search process even though all alternatives are immediately available.

2.5   Conclusion

In the experiment reported here, subjects have to choose a three-part tariff knowing that their demand would be equal to one out of eleven possible numbers, and there would be six demand realizations under the chosen tariff. This demand interval is symmetric around the mean, and hence, the expected demand is equal to the number in the middle of the interval. Subjects make the choice of a three-part tariff 27-30 times, with different tariffs being offered every time. The main result of the paper is that subjects are prone to choose the tariff with the number of included units equal to their expected demand even when this tariff is not the first-best choice.

The most compelling explanation for the observed bias is that the three-part tariff with the number of included units equal to the expected demand is in the experiment always the only one whose cost function is non-linear at the demand interval. This potentially makes subjects underestimate its expected cost. The second explanation that is consistent with the subjects' choices across experimental tasks and their mouse clicks during the information acquisition process is the "match" heuristic: Subjects are more likely to choose the scheme that seems to be a good fit to their demand type without comparing its expected cost with the cost of other schemes.

A preliminary implication of the reported experimental finding is that real-life consumers tend to react on labels and advertising campaigns according to how they perceive themselves. That is, if an offer is promoted as the one to suit student needs, then most students and only a few non-students would choose it. Students would be unlikely to check other offers, while non-students would be unlikely to check carefully this offer. For the regulating authorities this would mean a necessity to check whether "student offers" are indeed the ones to fit student needs the best.

2.6 Appendix

The Role of Risk Attitude

In the main part of the paper, I assume that consumers choose pricing schemes to maximize their expected earnings, which is equivalent to minimizing the expected cost of consumption. The assumption is justified by the experimental design feature that the chosen pricing scheme is valid for six consumption periods. Still, some readers believe that consumers' choices of pricing schemes might be affected by their risk attitude. Here, I show that even when risk attitude is taken into account, the main idea of the paper that subjects tend to simplify the problem and as a result mis-perceive the values of the offered pricing schemes still holds.

To show this, I derive predictions and compare the performance of two (in some sense) generalized decision rules. The first one is the maximization of per-period expected utility assuming the CARA utility function, $u\left(z\right) = \left(1 - exp\left(r_A z\right)\right) / \left(1 - exp\left(r_A\right)\right)$, where z is the amount of money, and r_A is the coefficient of absolute risk aversion and allowing for the coefficients of absolute risk-aversion to be equal to -0.1, -0.05, 0, 0.05, 0.10, and 0.15 (negative values represent risk-loving and 0 represents risk-neutrality). For every subject, I choose the coefficient that predicts the highest share of choices. The general predictions for the choices of risk-averse and risk-neutral consumers are the following:

Prediction RA. *Risk averse consumers tend to choose pricing schemes with a larger number of included units even when expected earnings under these schemes are lower than those under the pricing schemes with a lower number of included units.*

Prediction RL. *Risk loving consumers tend to choose pricing schemes with a lower number of included units even when expected earnings under these schemes are lower than those under the pricing schemes with a larger number of included units.*

The second decision rule is to maximize the payoff from either the minimum, the maximum, or the expected demand realization. Again for every subject, I choose the option that predicts the highest share of choices. The second decision rule, heuristics, outperforms the first one, optimization.

Result R1: *When subjects are assumed to use heuristics, 61.4% (s.e. .0088) of the choices can be explained. This is statistically higher than 59.1% (s.e. .0088) of choices the that can be explained with optimization.*

Results R2: *When only heuristics or optimization are compared, the heuristics are the best predictor for 53 subjects, and the optimization is the best predictor for 27 subjects.*

Instructions for the Experiment

General information

In this experiment, we study how consumers choose pricing schemes when their demand is uncertain. Hence, you will have to choose a pricing scheme 27 times. Every time when you choose a pricing scheme, you know that it will be used to determine your consumption expenditures in the subsequent consumption periods. In every consumption period, you will be endowed with a fixed budget and will be required to consume a certain number of units (to be explained below). The consumption expenditures will be subtracted from your budget, and the rest of the budget will be added to your experimental earnings.

Consumption periods

There are **27 tasks** in the experiment. Every task consists of a pricing-scheme choice (active part) and **6 consumption periods** (passive part). In each consumption period, you are endowed with a **budget**, and you are required to consume a certain **number of units**. You know the precise size of the budget, but **you do not know** the precise number of units that you will be required to consume. You only know the set from which this number will be randomly drawn by the computer.

Within one task, the budget is the same for each consumption period, but the number of units that you are required to consume is independently drawn for each period, so that it is likely to be different. Consumption periods constitute the passive part of the experiment because you are not required to do anything. You will only observe the realized number of units to be consumed, your earnings in each period of the task, and your total earnings in the task.

Pricing-scheme choice

All pricing schemes that will be offered to you have a common structure:

Fixed fee: how much you have to pay per period to get a corresponding number of included units.

Included units: how many units you get per period after paying the fixed fee.

Extra unit price: how much you have to pay for each unit consumed in addition to included units.

Your pricing-scheme choice will be valid for 6 consumption periods. You will have to make this choice 27 times. Before the experiment starts, you will go through a practice round where you will have to make the choice 2 times.

Determination of earnings

Your earnings from the experiment will be equal to the sum of your earnings in all experimental tasks; tasks of the practice round will not be counted. Your earnings from a particular task will be equal to the sum of your earnings in the 6 consumption periods. In every consumption period, earnings will be equal to the difference between the given budget and the consumption expenditures. The consumption expenditures will be determined by your pricing-scheme choice and the uncertainty realization for the number of units you will be required to consume.

Your total earnings will be displayed after you complete all 27 tasks.

Your expected earnings are in the range between **8000 ECU** and **12000 ECU***, depending on your pricing-scheme choice. Choices made by other participants have no effect on your earnings. However, if you are particularly unlucky with uncertainty realization, you may end up with negative earnings. In this case, we will pay you the guaranteed minimum of **4000 ECU**. Also, you may be particularly lucky with uncertainty realization and end up with **22000 ECU**. In this case, we will pay you everything that you will earn.

*ECU stands for "Experimental Currency Unit", **1 ECU = 0.05 CZK**.

Thus, your final earnings will be in the range between **200 CZK** and **1100 CZK** depending on both your effort and luck.

Other Rules

If you have a question or a technical problem, raise your hand.

You are not allowed to talk to each other. If you violate this rule, you will be asked to leave the lab without being paid even the guaranteed minimum.

You are allowed to take notes but only on the paper provided to you.

Before you start the experiment, you will see how it works in a practice round that consists of 2 tasks.

To start the practice round, fill in the login information provided to you and click the **"Start practice round"** button.

Table 2.8: The subjects' choices of pricing schemes and paired marginal homogeneity tests with the null-hypothesis that choice errors are random. Numbers in each cell of the main table are frequency, row percentage, and column percentage. Only data from the main 27 tasks are used.

1st-best scheme	Subjects' choice				
	Included 30	Included 40	Included 50	Included 60	**Total**
Included 30	**371**	111	345	127	**954**
	.389	.114	.362	.133	1
	.699	.151	.273	.399	.335
Included 40	72	**500**	269	113	**954**
	.076	**.524**	.282	.118	1
	.136	**.682**	.213	.355	.335
Included 50	88	122	**648**	78	**936**
	.094	.13	**.692**	.083	1
	.166	.166	**.514**	.245	.329
Total	531	733	1,262	318	**2,844**
	.187	.258	.444	.118	**1**
	1	1	1	1	**1**

marginal homogeneity test for:	chi-square
Included 30 - Included 50	216.12***
Included 30 x Included 40	8.31***
Included 30 x Included 50	152.54***
Included 40 x Included 50	55.27***

Table 2.9: The subjects' choices of pricing schemes depending on the parameter of which scheme has been opened first.

First characteristic opened belongs to scheme	Subjects' choice			
	Included 30	Included 40	Included 50	Included 60
Included 30 vs.	**.221 (.009)**	.243 (.01)	.4 (.011)	.137 (.008)
not Included 30	**.109 (.009)**	.266 (.013)	.468 (.015)	.157 (.011)
t-statistics	**7.83*****	-1.42*	-3.73***	-1.51*
Included 40 vs.	.09 (.016)	**.359 (.027)**	.424 (.028)	.127 (.019)
not Included 40	.192 (.007)	**.238 (.008)**	.423 (.009)	.146 (.007)
t-statistics	-4.54***	**4.76*****	.03	-.94
Included 50 vs.	.086 (.014)	.24 (.021)	**.531 (.024)**	.143 (.017)
not Included 50	.197 (.008)	.252 (.008)	**.406 (.001)**	.145 (.007)
t-statistics	-5.51***	-.53	**4.82*****	-.09
Included 60 vs.	.167 (.025)	.198 (.027)	.419 (.033)	**.216 (.028)**
not Included 60	.183 (.007)	.255 (.008)	.424 (.009)	**.139 (.006)**
t-statistics	-.6	-1.88**	-.14	**3.17*****
no scheme vs.	.131 (.031)	.23 (.038)	.459 (.045)	.18 (.035)
some scheme	.14 (.007)	.252 (.008)	.422 (.009)	.143 (.006)
t-statistics	-1.47*	-.55	.82	1.15

Figure 2.4: A screen-shot of an experimental task: the text in red is task and subject specific.

Pricing Scheme Choice. Task #1.

You need to select a pricing scheme.

Your pricing-scheme choice will be used to calculate your consumption expenditures.

Your consumption will last for 6 periods.

In every period, you will have a budget of 350 ECU.

In every period, you will have to consume X units.

X is determined as 50 + R, where R is randomly chosen by the computer, independently for every period.

R can take any of the following values, each value is equally possible: {-10, -8, -6, -4, -2, 0, 2, 4, 6, 8, 10}.

The following pricing schemes are offered. You need to click on a cell to see its value:

	Included 30	Included 40	Included 50	Included 60
Fixed Fee: how much you pay per period to get a corresponding number of included units	click to open	click to open	click to open	click to open
Included Units: how many units you get per period after paying a corresponding fixed fee	click to open	click to open	click to open	click to open
Extra Unit Price: how much you pay for each unit consumed in addition to included units	click to open	click to open	click to open	click to open

You can use the form below to perform necessary calculations.

[___] [◆] (Compute)

The calculator does not work if you leave any field empty.

To select a pricing scheme, click on the corresponding button:

(Included 30) (Included 40) (Included 50) (Included 60)

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Figure 2.5: A screen-shot of the feedback provided after every experimental task.

Summary for consumption periods. Task #1

Your pricing-scheme choice was: **Included 30**.

Period	Budget	Number of units to consume	Earnings
1	350 ECU	50 units	80 ECU
2	350 ECU	55 units	40 ECU
3	350 ECU	40 units	160 ECU
4	350 ECU	43 units	136 ECU
5	350 ECU	45 units	120 ECU
6	350 ECU	46 units	112 ECU

Your earnings in **Task #1** are **648 ECU**.

If anything is unclear, raise your hand. Otherwise, you can proceed.

(Next Task)

Figure 2.6: A screen-shot of the summary page of the experiment.
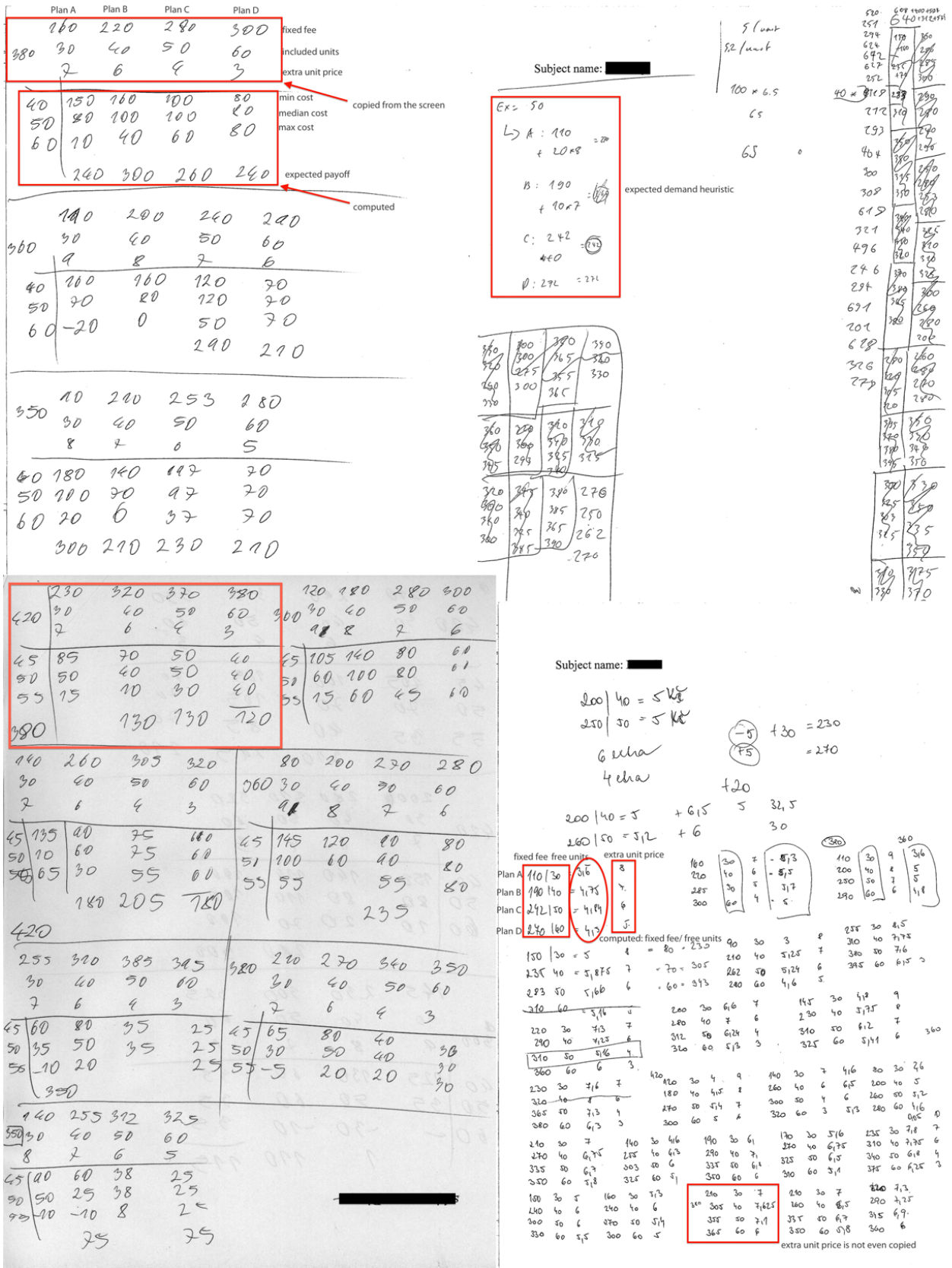
Summary.

Your total earnings are **11682 ECU**.

So, we will pay you **526 CZK**

Raise your hand to call the experimenter to pay you.

Meanwhile, you can fill in the payment form.

Figure 2.7: Four types of the subjects' notes during the experiment.

Chapter 3
Price Discrimination with Boundedly Rational Consumers: When to Make Dominated Offers?

I suggest a bounded rationality explanation for the presence of dominated choice alternatives in markets. By dominated alternatives I mean those that are never chosen by fully rational consumers. These are alternatives that violate consumers' participation or incentive compatibility constraints. The model is built upon the assumption that, due to time or cognitive limitations, consumers have only a sub-set of available alternatives in their consideration sets, from which they choose the best ones. The necessary condition for the monopolist to benefit from offering dominated alternatives is that consumers with a higher willingness to pay are more likely to have them in their consideration sets.
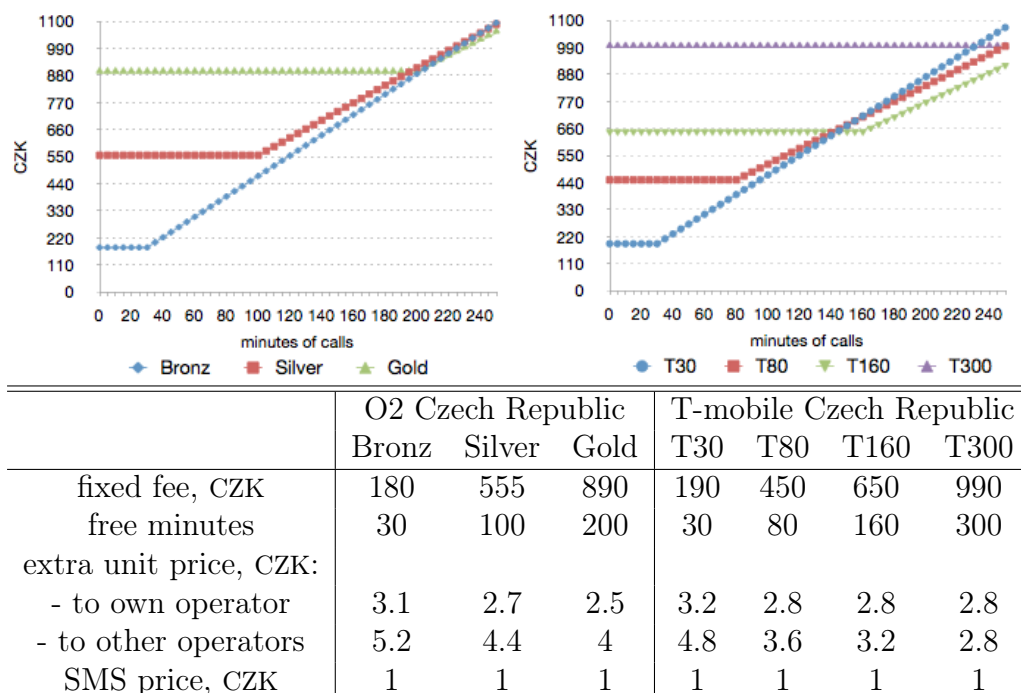
3.1 Introduction

Consider the problem of traveling from city A to city B. There are several train and bus options available. As it is generally believed, trains are more comfortable than buses, even though there might be individual buses being more comfortable than individual trains. Consumers have search costs, and they rarely consider all available options before deciding to take one of them (unless they have a PhD in economics). Assume that the population of consumers can be roughly divided into those with a high and a low willingness to pay for the comfort. In this case, the first group of consumers would be more likely to search among train options, while the second group will focus on bus options. Within each category, each consumer type will search for the best quality-price combination. At the end, it is likely that the quality-price combination of the train option chosen by a consumer with a high willingness to pay will be dominated by some existing bus option.

The main idea behind the situation described above is that when consumers search, those with a high willingness to pay consider different market alternatives than those with a low willingness to pay. Firms who can price discriminate against such consumers might also exploit their differences in search behavior. In that case, they extract a higher share of consumer surplus by selling "dominated" offers. To clarify what I mean by "dominated" offers, I provide another example from the Czech mobile phone market (Table 3.1).

This example is about standard three-part tariffs (i.e. a fixed fee, a bundle of included calls, and a unit price for additional calls). In the Czech Republic, Telefonica O2 had five such tariffs, and T-mobile had six of them in 2008. A noteworthy observation is that the O2 plan "Silver" is more expensive than "Bronz" and the T-mobile plan "T80" is more expensive than "T30" for a large consumption range. This range includes up to about 200 minutes of calls for O2 and up to about 140 minutes of calls for T-mobile.

The experimental evidence documented in Chapter 2 of this dissertation suggests that consumers are more likely to consider those options that "match" their demand expectations. For the case of three-part tariffs, these are the tariffs with included calls equal to the expected consumption level. That is, O2 consumers who expect to make 100 minutes of calls are more likely to consider "Silver" than "Bronz". Similarly, T-mobile consumers who expect to make 80 minutes of calls per month are more likely to consider "T80" than "T30". This indicates a tendency among consumers to choose dominated options. Correspondingly, by offering such options, firms can potentially extract a higher share of consumer surplus.

Table 3.1: Mobile phone tariffs offered in the Czech Republic by the major operators in 2008. Graphs assume that at least 50% of calls terminate at the home network.

	O2 Czech Republic			T-mobile Czech Republic			
	Bronz	Silver	Gold	T30	T80	T160	T300
fixed fee, CZK	180	555	890	190	450	650	990
free minutes	30	100	200	30	80	160	300
extra unit price, CZK:							
- to own operator	3.1	2.7	2.5	3.2	2.8	2.8	2.8
- to other operators	5.2	4.4	4	4.8	3.6	3.2	2.8
SMS price, CZK	1	1	1	1	1	1	1

Some would argue that pricing practices documented in Table 3.1 might be beneficial for certain segments of consumers. Their argument could be that consumers get a higher discount on a mobile phone when it is purchased with a bigger pricing plan (i.e. it has more included calls and a higher fixed fee). Such extra benefits might explain why consumers choose plans like "Silver" and "T80".

In this paper, I study a simplified model that allows me to address the question whether firms have incentives to offer truly dominated alternatives, that is, such alternatives that no consumers would rationally choose. For that, I introduce a particular type of consumer cognitive constraint: They can only compare a limited number of alternatives, but always choose the best one from those compared, or an outside option.

The main result of the paper is that this type of consumers' cognitive constraint *per se* does not make it profitable for firms to offer dominated alternatives. The necessary condition for this to happen is that consumers with a higher willingness to pay are more likely to have a dominated alternative in their consideration set.

The presence of dominated price offers seems to be typical not only for the Czech mobile phone market. For instance, Miravete 2007 reports that every second company

in the early U.S. cellular phone industry (1988 to 1992)[1] has been offering at least one dominated tariff before competition was introduced in the market. The situation changed with the competition as new entrants were offering mainly non-dominated tariffs.

In this paper, I study a monopolist's problem of what tariffs to offer to boundedly rational consumers, without considering the effect of competition. My aim is to illustrate how predictions of the conventional theory change when consumers deviate from fully rational behavior.[2]

In what follows, I describe the model and provide reasoning that leads to the main result. Two versions of limitations imposed on the consumer behavior are used. In the first case, they evaluate only one bundle from those offered to them. They accept the bundle as long as it satisfies their participation constraint. In the second case, consumers compare two bundles. They choose the best from those compared, as long as it is better than the outside option. These two cases are sufficient to illustrate the intuition behind the main result.

3.2   Model

A consumer's utility from consumption is characterized with a function $u(\theta_i, q)$, where θ_i defines the consumer type and q measures his consumption. In this paper, I restrict the analysis to the case of two consumer types: low with the probability λ and high with the probability $1 - \lambda$. Standard constraints on the form of the utility function are imposed: $u_q > 0$, $u_{qq} < 0$, $u(\theta_i, 0) = 0$, $u(\theta_H, q) > u(\theta_L, q) \ \forall q > 0$, and $u_q(\theta_H, q) > u_q(\theta_L, q) \ \forall q$.

The monopolist offers N alternatives to the consumer. $T_j = (q_j, t_j)$ describes an alternative j, where q_j is the consumption level, and t_j is the price. Hence, the choice alternative is a bundle.[3] The consumer can choose only one bundle, and he can also choose none. The latter one is an important assumption. In that case, consumption

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[1]In the mid-1980s, there were about 300 non-overlapping cellular phone markets in the U.S., almost all of them started with the monopoly stage and the duopoly was introduced shortly after that.

[2]It would be interesting to study how the competitive outcome is affected by the presence of boundedly rational consumers. However, models of non-linear pricing in the context of competing firms are not well developed yet, even assuming that consumers are fully rational. That is one reason why I focus on the monopolist's pricing strategies in this paper and leave competitive markets for future research.

[3]In the model, I consider bundles, as opposed to three-part tariffs used in the motivating example. One reason to do so is to stay close to the traditional price discrimination literature, mostly familiar to the reader, and to use its main results. Another reason is that three-part tariffs can be treated as an implementation of the optimal menu of bundles for a large number of consumers types (see Bagh and Bhargava 2008). As there are only two consumer types in my model and the monopolist can offer an unlimited number of simpler pricing schemes, three-part tariffs become irrelevant.

and, correspondingly, utility are equal to 0. The monopolist's marginal cost, $c > 0$, is constant.

The consumer knows his type when he chooses a bundle. The monopolist does not know the consumer type when he designs and sells bundles. I first characterize the standard solution to the monopolist's price discrimination problem when the consumer is fully rational and choosing a bundle is not associated with any kind of costs for him. Then, I show how this solution is affected by the consumer's inability to compare all bundles. This inability can be motivated by zero choice cost for a particular number of bundles and an infinitely large choice cost when the consumer considers an extra bundle.[4]

3.2.1 Rational Consumers

Under the assumption of risk neutrality, the fully rational consumer always chooses the bundle that maximizes his net suplus V_{ij}, regardless of the number of available bundles:

$$\max_{j} V_{ij} = u\left(\theta_i, q_j\right) - t_j, \text{ for } i = L, H. \tag{3.1}$$

By selling bundle T_j, the monopolist receives the price t_j and incurs the cost cq_j. Hence, the social value of bundle T_j chosen by the θ_i-type consumer is equal to:

$$p_{ij} = u\left(\theta_i, q_j\right) - cq_j. \tag{3.2}$$

I restrict further analysis to the cases when the social value of all bundles is positive. One of the standard results is that in the full information case, when the monopolist can directly observe the consumer type, he offers the socially optimal level of consumption and extracts the whole consumer surplus. This is defined as the first-best outcome.

Definition 1. The first-best outcome is bundle T_l^* for the θ_L-type, and bundle T_h^* for the θ_H-type such that:

$$q_j^* = \arg\max_{q} \left[u\left(\theta_i, q\right) - cq\right], \tag{3.3}$$

$$t_j^* = u\left(\theta_i, q_j^*\right), \tag{3.4}$$

where $j = l$ when $i = L$, and $j = h$ when $i = H$.

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[4]In the present paper, I use the consumer's inability to compare all bundles as an assumption. In future research, I would like to model it as a consequence of a positive choice cost.

When the monopolist cannot directly observe θ_i, he tries to screen the consumer type. He offers two bundles, T_l and T_h, such that the consumer self-selects into the bundle T_l if his type is θ_L and into the bundle T_h if his type is θ_H. In this case, the monopolist has the following profit function.

$$\pi^{SB} = \lambda(t_l - cq_l) + (1 - \lambda)(t_h - cq_h), \tag{3.5}$$

subject to the following set of constraints:

$$V_{Ll} \geq 0 \; [PC_L], \tag{3.6}$$

$$V_{Hh} \geq 0 \; [PC_H], \tag{3.7}$$

$$V_{Ll} \geq V_{Lh} \; [ICC_L], \tag{3.8}$$

$$V_{Hh} \geq V_{Hl} \; [ICC_H]. \tag{3.9}$$

Another standard result is that the monopolist can ignore PC_H and ICC_L, and he makes PC_L and ICC_H binding in the optimum. The profit maximization problem becomes:

$$\max_{q_l, q_h} \left[\lambda p_l + (1 - \lambda)[p_h - V_{Hl}] \right], \tag{3.10}$$

$$\text{where } p_l = u(\theta_L, q_l) - cq_l, \tag{3.11}$$

$$p_h = u(\theta_H, q_h) - cq_h, \tag{3.12}$$

$$V_{Hl} = u(\theta_H, q_l) - u(\theta_L, q_l). \tag{3.13}$$

The solution is defined as the second-best outcome:

Definition 2. The second-best outcome is the bundle T_l^{SB} for the θ_L-type and the bundle T_h^{SB} for the θ_H-type such that:

$$q_l^{SB} = \arg\max_q \left[\lambda p_l - (1 - \lambda)V_{Hl} \right] < q_l^*, \tag{3.14}$$

$$q_h^{SB} = \arg\max_q (1 - \lambda)p_h = q_h^*, \tag{3.15}$$

$$t_l^{SB} = u\left(\theta_L, q_l^{SB}\right) < t_l^*, \tag{3.16}$$

$$t_h^{SB} = u\left(\theta_H, q_h^*\right) - V_{Hl}^{SB} < t_h^*. \tag{3.17}$$

It is optimal for the monopolist to provide the θ_H-type with his first-best level of con-

sumption and to induce a downward distortion in the consumption of the θ_L-type.[5] This leads to a reduction of social welfare. The θ_H-type receives a positive net surplus, while the net surplus of the θ_L-type is zero. This reallocation of surplus from the monopolist to the consumer does not directly affect the social welfare, but lowers the monopolist's profit. In what follows, I show that the distortion in the consumption of the θ_L-type can be reduced in the precence of boundedly rational consumers.

The second-best profit can be expressed as:

$$\pi^{SB} = \lambda p_l^{SB} + (1 - \lambda)[p_h^* - V_{Hl}^{SB}]. \tag{3.18}$$

It is higher than the profit from offering T_l^* alone when

$$(1 - \lambda)V_{Hl}^{SB} - \lambda p_l^{SB} < (1 - \lambda)p_h^* - p_l^*, \tag{3.19}$$

and it is higher than the profit from offering T_h^* alone when

$$(1 - \lambda)V_{Hl}^{SB} - \lambda p_l^{SB} < 0. \tag{3.20}$$

For the special case when $(1 - \lambda)p_h^* = p_l^*$, these conditions are equivalent.

3.2.2 Boundedly Rational Consumers: One Bundle Considered

Consider the following consumer behavior. The consumer knows his type. All alternatives offered by the monopolist are available to the consumer, but he can compute his net surplus for only one alternative, regardless of the total number. That is, his consideration set consists of one alternative. If the net surplus of this alternative is nonnegative, then the consumer buys it. Otherwise, he does not buy anything. I define this as the $C(1)$ procedure.

Assume that the probability that the consumer has a particular alternative in his consideration set does not depend on the actual value of this alternative, which is equal to the consumer's net surplus. The reason is that having an alternative in the consideration set implies being able to compute its type-specific value. If type-specific values of all alternatives are explicitly given, which is rarely the case, then the model is not applicable.

When the consumer behaves as described above, the monopolist's profit function from

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[5]The downward distortion in q_l is the case because $u_q(\theta_L, q_l^{SB}) > c$, and $u_q(\theta_L, q_l^*) = c$, while $u_{qq} < 0$.

offering N bundles can be represented as follows:

$$\pi^{C(1)} = \sum_{j=1}^{N} (t_j - cq_j)[\lambda s_L^j f(V_{Lj}) + (1-\lambda)s_H^j f(V_{Hj})], \tag{3.21}$$

$$\text{where } f(V_{ij}) = \begin{cases} 1 \text{ if } V_{ij} \geq 0 \\ 0 \text{ otherwise} \end{cases} \quad \text{for } i = L, H \tag{3.22}$$

$$\text{and } \sum_{j=1}^{N} s_i^j = 1 \text{ for } i = L, H, \tag{3.23}$$

where s_i^j is the probability that the consideration set of the θ_i-type consists of an alternative j, and $f(V_{ij})$ is the decision rule of the θ_i-type who has an alternative j in his consideration set that tells him whether to buy this alternative or not. Each element of the profit function is the monopolist's profit from selling a particular bundle weighted by the probability that the corresponding consumer type has this bundle in his consideration set, and conditioned on that this consumer type extracts a non-negative net surplus from this bundle.

Before stating the main result, I make two important observations. The first one implies that it is no longer optimal to offer the second-best bundles (T_l^{SB}, T_h^{SB}) when the consumer behaves according to the $C(1)$ procedure.

Lemma 1. *Assume that the consumer chooses according to the $C(1)$ procedure. Every bundle that the monopolist offers is the first-best for at least one consumer type.*

Proof. First, assume that the monopolist offers **only one bundle**. Then, even with the fully rational consumer, there are no incentive compatibility constraints. The monopolist can either serve both consumer types or completely exclude the θ_L-type. In the first case, the PC_L constraint is binding. Taking this into account, the profit function becomes

$$\pi_{T_l^*}^{C(1)} = p_l^*. \tag{3.24}$$

The optimal bundle in this case is the first-best bundle for the θ_L-type. In the second case, the PC_H constraint is binding, and the profit function reduces to the following:

$$\pi_{T_h^*}^{C(1)} = (1-\lambda)p_h^*. \tag{3.25}$$

The optimal bundle in this case is the first-best bundle for the θ_H-type.

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I present this standard analysis of pooling and excluding solutions here because the logic extends to the case when the monopolist offers **more than one bundle** to the consumer who follows the $C(1)$ choice procedure. This is so because incentive compatibility constraints are irrelevant under this assumption on consumer behavior.

Assume that the monopolist offers N bundles such that $M < N$ bundles leave a non-negative net surplus to both consumer types, while the remaining $N - M > 0$ bundles exclude the θ_L-type. Then the PC_L will bind for M bundles, and the PC_H will bind for the remaining $N - M$ bundles. The monopolist's profit function becomes

$$\pi_{T_l, T_h}^{C(1)} = \sum_{j=1}^{M} (\lambda s_L^j + (1-\lambda) s_H^j) p_l + \sum_{j=M+1}^{N} s_H^j (1-\lambda) p_h. \tag{3.26}$$

Optimally, the first M bundles are equivalent to the first-best bundle of the θ_L-type, T_l^*, and the remaining $N - M$ bundles are equivalent to the first-best bundle of the θ_H-type, T_h^*, because the monopolist has incentives to maximize the social welfare. $\qquad\square$

The intuition behind Lemma 1 is rather straightforward. The θ_H-type buys any bundle from his consideration set that satisfies his participation constraint. It makes no sense to offer a bundle that does not satisfy PC_H. Leaving any information rent to the θ_H-type makes sense only if the monopolist wants the θ_L-type to choose this bundle. Leaving any information rent to the θ_L-type makes no sense. As the monopolist can extract the full surplus of the θ_H-type without distorting the consumption of the θ_L-type, it is suboptimal to impose any distortions. Effectively, the monopolist offers at most two distinct bundles, a notion that deserves some discussion.

Definition 3. Bundles T_j and T_k are distinct if $t_j \neq t_k$, or $q_j \neq q_k$ when both j and k satisfy PC_H. When both bundles violate PC_H, they are treated as identical. [6]

The notion of distinct bundles together with equation (3.26) brings up an interesting issue. The monopolist can affect his profit by altering M and N, the number of bundles equivalent to T_l^* and to T_h^*. The effect comes from a change in the probability that a particular consumer type will check a bundle equivalent to the bundle T_h^*. The higher

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[6] The second part of the definition becomes important when the consumer can have two alternative in his consideration set. In that case, it might be optimal for the monopolist to offer a bundle that violates PC_H. The purpose of such bundle is to relax the incentive compatibility constraint of the θ_H-type for the second bundle in his consideration set. The parameters of such bundle are not well-defined because it is possible to achieve $V_{Hj} < 0$ with a large number of combinations (q_j, t_j).

this probability is for the θ_L-type, $s_L^h = \sum_{j=M+1}^{N} s_L^j$, the lower the profit. The higher this probability is for the θ_H-type, $s_H^h = \sum_{j=M+1}^{N} s_H^j$, the higher the profit.[7]

The second important observation implies that the monopolist never offers more than two distinct bundles.

Lemma 2. *Assume that the consumer chooses according to the $C(1)$ procedure. The optimal number of distinct bundles never exceeds the number of consumer types.*

Proof. The result follows directly from Lemma 1, particularly from equation (3.26). There, the first M bundles are all equivalent to the bundle T_l^*, and the remaining $N - M$ bundles are all equivalent to the bundle T_h^*. All together, there are at most two distinct bundles when there are two consumer types. □

Based on Lemma 1 and Lemma 2, there are only three possible optimal pricing strategies for the monopolist, when the consumer chooses according to the $C(1)$ procedure. These strategies are the following: (a) to offer a single bundle T_l^*, (b) to offer a single bundle T_h^*, and (c) to offer both T_l^* and T_h^*. The choice over these three strategies depends on the probability that the consumer is of a particular type, on the parameters of the utility function, and on the probability that a particular consumer type has a particular bundle in his consideration set. The central result is stated below.

Proposition 1. *Assume that the consumer chooses according to the $C(1)$ procedure. It is optimal for the monopolist to offer two distinct bundles T_l and T_h **only if** the bundle T_h is more likely to be in the consideration set of the θ_H-type consumer than in the consideration set of the θ_L-type consumer, i.e., $s_H^h > s_L^h$.*

Proof. By Lemma 1, if the monopolist offers two distinct bundles, these are the first-best best bundles T_l^* and T_h^*. The profit, in this case, is equal to

$$\pi_{T_l^*, T_h^*}^{C(1)} = (\lambda s_L^l + (1 - \lambda) s_H^l) p_l^* + (1 - \lambda) s_H^h p_h^*. \tag{3.27}$$

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[7]The model that I study in this paper is restrictive in the sense that it does not endogenize the probabilities s_L^h and s_H^h. One seemingly natural way to endogenize them would be through the choice of N and M. However, this would not solve the problem because ad hoc assumptions on the nature of s_L^j and s_H^j would still have to be made. A preferred solution would be to model how the structure and the parameters of offered bundles, together with the way how the monopolist advertises the bundles, affect the probabilities that different consumer types have them in their consideration sets. I leave this for future research with a comment in the concluding section. In this paper, I focus on the requirements that need to be imposed on s_L^h and s_H^h to achieve desirable results.

The profit from offering both bundles T_l^* and T_h^* is higher than the profit from offering only the first-best bundle T_l^*, which is equal to p_l^*, when the following condition is satisfied (note that $s_i^l = 1 - s_i^h$):

$$(1 - \lambda)s_H^h p_h^* > (\lambda s_L^h + (1 - \lambda)s_H^h)p_l^*. \tag{3.28}$$

The profit from offering only T_h^* is equal to $(1 - \lambda)p_h^*$. The profit from offering both T_l^* and T_h^* is higher than this when the following condition is satisfied:

$$(1 - \lambda s_L^h - (1 - \lambda)s_H^h)p_l^* > (1 - \lambda)(1 - s_H^h)p_h^*. \tag{3.29}$$

To guarantee that offering two distinct bundles is more profitable than offering a single bundle, conditions (3.28) and (3.29) should be satisfied simultaneously. This leads to the following condition:

$$1 - \lambda \frac{s_H^h - s_L^h}{s_H^h} < \frac{(1 - \lambda)\,p_h^*}{p_l^*} < 1 + \lambda \frac{s_H^h - s_L^h}{1 - s_H^h}. \tag{3.30}$$

By Lemma 2, the three pricing stretegies considered above are the only possible optimal strategies. Hence, the condition (3.30) is the sufficient condition for the offer of two distinct first-best bundles T_l^* and T_h^* to be the optimal strategy. The condition (3.30) is satisfied only if $s_H^h > s_L^h$, which proves the proposition. $\square$

It follows from the condition (3.30) that the bigger the difference between s_H^h and s_L^h, the more likely it is that the monopolist benefits from offering both bundles. In the extreme case with $s_H^h = 1$ and $s_L^h = 0$, the monopolist always offers both bundles. In the special case when $(1 - \lambda)\,p_h^* = p_l^*$, the necessary condition is also sufficient.

In this context, T_h^* is a **dominated bundle** for both consumer types. When both bundles T_l^* and T_h^* are in the consideration set, T_h^* is not chosen by any of the two possible consumer types. This is the definition of dominated bundles that I use in this paper.

Definition 4. A bundle T_j is the dominated one for the θ_i-type consumer if he never chooses this bundle when all available bundles are in his consideration set.

For future discussion, it is important to realize that all bundles that violate the consumer's incentive compatibility constraints are dominated for him. The presence of dominated bundles is justified by the consumer's failure to include all available bundles into the consideration set.

Profitability of dominated bundles due to the presence of boundedly rational consumers is the central question of this paper. For the consumer who follows the $C(1)$ procedure, I showed that this would not be the case unless the consumer with a higher willingness to pay has a higher probability of having the dominated bundle T_h^* in his consideration set. In the next section, I show that a similar condition is required when consumers' cognitive abilities are less limited.

3.2.3 Boundedly Rational Consumers: Two Bundles Considered

In the previous section, including an additional bundle into the consideration set is too costly for the consumer. Hence, he does not buy anything if the only bundle included into the consideration set is worse than the outside option. In this case, the monopolist may benefit from offering two first-best bundles T_l^* and T_h^* if the θ_H-type consumer has a higher probability of having the dominated bundle T_h^* in his consideration set. It is never optimal to offer more than two distinct bundles nor to offer two second-best bundles. In this section, I extend these results.

Here, the consumer has two bundles in his consideration set and chooses the best out of them. If both give him a negative net surplus, the consumer does not buy anything. I define this as the $C(2)$ procedure. In this paper, I do not allow the consumer to choose whether to follow $C(1)$, $C(2)$, or a more advanced procedure. His choice procedure is an exogenous constraint which is known ex ante to the monopolist.

When the consumer behaves according to the $C(2)$ choice procedure, the monopolist's profit function from offering N bundles can be written in the following way:

$$\pi^{C(2)} = \sum_{j=1}^{N}(t_j - cq_j)[\lambda \sum_{\forall k \neq j} s_L^{jk} f(V_{Lj}, V_{Lk}) + (1-\lambda) \sum_{\forall k \neq j} s_H^{jk} f(V_{Hj}, V_{Hk})] \quad (3.31)$$

$$\text{where } f(V_{ij}, V_{ik}) = \begin{cases} 1 \text{ if } [V_{ij} > V_{ik} \cup (V_{ij} = V_{ik} \cap q_j > q_k)] \cap V_{ij} \geq 0 \\ 1/2 \text{ if } T_j = T_k \\ 0 \text{ otherwise} \end{cases} \quad (i = L, H),$$

where s_i^{jk} is the probability that the θ_i-type has bundles j and k in his consideration set, and $f(V_{ij}, V_{ik})$ is his choice rule in this case. The choice rule is sensitive to the order of its arguments, i.e. $f(V_{ij}, V_{ik}) = 1 - f(V_{ik}, V_{ij})$, and the first bundle, T_j, is the one to which the choice rule is applied.

Under the standard restrictions imposed on the utility function, most importantly, the single crossing property, only the following four types of bundles are feasible and might be profitable for the monopolist to offer: (1) T_a such that $V_{La} = 0$ and $V_{Ha} > 0$; (2) T_b such that $V_{Lb} < 0$, $V_{Hb} = V_{Ha}$, and $q_b > q_a$; (3) T_c such that $V_{Lc} < 0$ and $V_{Hc} = 0$; and (4) T_d such that $V_{Ld} < 0$ and $V_{Hd} < 0$.[8] In principle, there might be several bundles within each category, but as I show later, they would not be distinct bundles.

The θ_L-type buys only the T_a bundle as long as he has it in the consideration set. Otherwise, he does not buy anything. This explains why offering T_a might be optimal. More importantly, the θ_H-type buys the T_a bundle when he compares it with the T_c and T_d bundles, and he buys T_b bundle when he compares it with the T_a, T_c, and T_d bundles. This explains why offering T_b might be optimal. This bundle might be needed only when the bundle T_a is offered. Only with the T_c bundle the monopolist can extract the whole surplus of the θ_H-type. This is why offering T_c might be optimal. However, the θ_H type buys the T_c bundle when he has only T_c and T_d in the consideration set. To make it possible, the monopolist should add T_d every time he adds T_c. Otherwise, T_c is always compared with a better bundle and, hence, is never chosen.

A further analysis of the profit function leads to the following conclusion:

Lemma 3. *Assume that the consumer chooses according to the $C(2)$ procedure. Only the following pricing strategies can be optimal: (1) a single bundle T_a or T_c; (2) two bundles T_a and T_b; (3) three bundles T_a, T_c, and T_d; and (4) four bundles T_a, T_b, T_c, and T_d.*

Proof. In Appendix. $\square$

It follows that the bundle T_c is always equivalent to the first-best bundle of the θ_H-type, T_h^*. The bundle T_a is equivalent to the first-best bundle of the θ_L-type, T_l^*, when it is offered without the bundle T_b. When bundles T_a and T_b are offered together, there is a distortion in q_a and a positive net surplus is left to the θ_H-type (because the incentive compatibility of T_b with respect to T_a for the θ_H-type has to be maintained).

The monopolist's choice of a particular strategy listed in Lemma 3 naturally depends on the differences in the parameters of the utility function and in the choice behavior of each consumer type, as well as on λ. The higher the monopolist's expected profit is from serving the θ_H-type compared to serving the θ_L-type, the more likely he is to offer

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[8]A bundle T_j such that $V_{Lj} \geq 0$ and $V_{Hj} \leq 0$ is impossible due to the restriction on the utility function that $u(\theta_H, q) > u(\theta_L, q) \ \forall q > 0$. A bundle T_j such that $V_{Lj} > 0$ and $V_{Hj} > 0$ is never profitable because the monopolist can extract the whole surplus of the θ_L-type without any trade-off.

the bundle T_h^* alone. If the difference in profits from serving θ_H- and θ_L-types is not sufficiently high, the monopolist would be better off by offering a mixture of bundles or the bundle T_l^* alone.

The focus of this paper is on the necessary conditions under which offering dominated bundles is optimal for the monopolist. Notice in Lemma 3 that the dominated bundles are a part of the optimal pricing strategy only when three or four bundles are offered. In both cases, these are two bundles, T_h^* and T_d. Neither of them would be ever chosen by a fully rational consumer nor by the consumer who follows the $C(2)$ procedure and has only one of them in his consideration set. In general, offering a single dominated bundle is never profitable when the consumer follows the $C(2)$ choice procedure. The latter explains why these bundles have to be offered together. In that case, the $C(2)$ consumer chooses T_h^*.

Proposition 2 extends the central result of the paper, summarized in Proposition 1 for the consumer who follows the $C(1)$ choice procedure.

Proposition 2. *Assume that the consumer chooses according to the $C(2)$ procedure. It is optimal for the monopolist to offer dominated bundles T_h^* and T_d **only if** the θ_H-type is more likely to have only dominated bundles in his consideration set than the θ_L-type.*

Proof. The claim made in the proposition implies that $s_H^{hd} > s_L^{hd}$ when three bundles T_l^*, T_h^* and T_d are offered, and $r_H^{hd} > r_L^{hd} + r_L^{bd} + r_L^{bh}$ when four bundles T_a, T_b, T_h^* and T_d are offered (to distinguish these two cases, I use s_i^{jk} and r_i^{jk} for the corresponding probabilities when three or four bundles are offered). The latter is the case because T_b is dominated for the θ_L-type. To prove the claim, I derive the necessary conditions for pricing strategies (T_l^*, T_h^*, T_d) and (T_a, T_b, T_h^*, T_d) to be optimal. For those conditions, as well as sufficient conditions for these pricing strategies being optimal, see Appendix. $\square$

The reader might be interested in learning what determines whether the strategy (T_a, T_b, T_h^*, T_d) or (T_l^*, T_h^*, T_d) is profitable. This, of course, depends on the probabilities for each consumer type to have particular bundles in his consideration set in each case. To see the condition more clearly, note that the monopolist's profit from the pricing strategy (T_l^*, T_h^*, T_d) has the following lower bound:

$$\pi_{T_a,T_b,T_h^*,T_d}^{C(2)} \geq (\lambda r_L^{a\cdot} + (1-\lambda)(r_H^{ah} + r_H^{ad}))p_l^* - (1-\lambda)r_H^{b\cdot}V_{Hl}^* + (1-\lambda)(r_H^{b\cdot} + r_H^{hd})p_h^* \quad (3.32)$$

because the monopolist can adjust the distortion in q_a and the net surplus left to the

θ_H-type if this increases his profit. This profit is higher than the profit from the pricing strategy (T_a, T_b, T_h^*, T_d) when the following inequality holds:

$$(\lambda(r_L^{a\cdot} - s_L^l) + (1-\lambda)(r_H^{ah} + r_H^{ad} - s_H^{l\cdot}))p_l^* + (1-\lambda)(r_H^{b\cdot} + r_H^{hd} - s_H^{hd})p_h^* > (1-\lambda)r_H^{b\cdot}V_{Hl}^*, \quad (3.33)$$

which is as likely to be satisfied as violated.

The purpose of this section was to show that the result obtained for the $C(1)$ consumer holds also when the consumer can have more market alternatives in his consideration set. The result is that the presence of consumers with limited cognitive abilities *per se* does not make it optimal for the monopolist to offer bundles that violate incentive compatibility constraints. The necessary condition for such bundles to be a part of the optimal pricing strategy is that the consumer with a higher willingness to pay is more likely to have dominated bundles in his consideration set than the consumer with the lower willingness to pay (remember that dominated bundles might be different for different consumer types). The patterns of the profit function documented in this section suggest that this condition would be required also in more general cases.

3.3   Concluding Remarks

In this paper, I study price discrimination with two consumer types when the consumer's cognitive abilities are limited. The limitation that I introduce is the following: a consumer has only an ex ante determined number of available alternatives in his consideration set, but he always chooses the best alternative from this set. If none of the compared alternatives is preferred to the outside option, then the consumer does not buy anything.

The main result of the paper is that the monopolist can only exploit this type of consumers' cognitive constraints when consumers of different types have different alternatives in their consideration sets. Particularly, consumers with a lower willingness to pay should be less likely to have dominated choice alternatives in their consideration set than consumers with a higher willingness to pay.

The reason underlying the result is that dominated options would violate the participation constraint of consumers with a lower willingness to pay and the incentive compatibility constraint of consumers with a higher willingness to pay. One of them would still satisfy the participation constraint of consumers with a higher willingness to pay. Hence, consumers with a lower willingness to pay would walk away, while consumers with

a higher willingness to pay would generate a higher profit for the monopolist.

It is natural to ask whether the condition specified above is likely to hold. Evidence documented in Chapter 2 of this dissertation suggests an affirmative answer. There I observe that subjects who are assigned 50 units of expected consumption are more likely to choose the three-part tariff with 50 units of included consumption than any other tariff, even when this tariff is the dominated one. Moreover, the probability to choose this dominated tariff is higher when the proper tariff is further away, i.e. has 30 rather than 40 units of included consumption. Another result in this experimental study is that subjects are more likely to start the choice process from the tariff with 50 units of "free" consumption (compared to the tariffs with 40 or 60 units), especially, when this information is reflected in the labels of the tariffs.

The experimental evidence can be interpreted as a possibility for firms to suggest to consumers which tariffs to compare by the means of appropriate characteristics (e.g. number of included units). Such suggestions would be consumer specific as opposed to the standard advertising of particular tariffs. This would help firms to ensure that different types of consumers have different tariffs in their consideration sets and make it optimal to offer dominated tariffs.

3.4 Appendix

When the consumer behaves according to the $C(2)$ choice procedure, the monopolist's profit function from offering N bundles is the following:

$$\pi^{C(2)} = \sum_{j=1}^{N}(t_j - cq_j)[\lambda \sum_{\forall k \neq j} s_L^{jk} f(V_{Lj}, V_{Lk}) + (1 - \lambda) \sum_{\forall k \neq j} s_H^{jk} f(V_{Hj}, V_{Hk})] \quad (3.34)$$

$$\text{where } f(V_{ij}, V_{ik}) = \begin{cases} 1 \text{ if } [V_{ij} > V_{ik} \cup (V_{ij} = V_{ik} \cap q_j > q_k)] \cap V_{ij} \geq 0 \\ 1/2 \text{ if } T_j = T_k \\ 0 \text{ otherwise} \end{cases} \quad (i = L, H).$$

Below, I prove Lemma 3 that characterizes the only possible optimal pricing strategies when consumers choose according to the $C(2)$ procedure. The proof is based on the observation that due to the constraints imposed on the utility function, the only feasible and potentially optimal types of bundles are the following: (1) T_a such that $V_{La} = 0$ and $V_{Ha} > 0$; (2) T_b such that $V_{Lb} < 0$ and $V_{Hb} = V_{Ha}$; (3) T_c such that $V_{Lc} < 0$ and $V_{Hc} = 0$; and (4) T_d such that $V_{Ld} < 0$ and $V_{Hd} < 0$.

In words, T_a is the bundle that extracts the whole surplus of the θ_L-type; T_b is the bundle which is incentive compatible with T_a for the θ_H-type; T_c is the bundle that extracts the whole surplus of the θ_H-type; and T_d is the bundle that creates a possibility that the θ_H-type compares T_c with neither T_a nor T_b, which both give the θ_H-type a positive net surplus. In the proof of Lemma 3, I use the following lemma saying that it is never optimal for the monopolist to offer two distinct bundles of the same type.

Lemma 4. *Assume that the consumer chooses according to the $C(2)$ procedure. Bundles of the types T_a, T_b, T_c, and T_d, as defined above, are available to the monopolist. It is never optimal for the monopolist to offer more than one distinct bundle of each type.*

Proof. The statement is true by the definition of distinct bundles when it is applied to bundles of the type T_d. Every other bundle of this type is defined to be equivalent to the existing one. Hence, there cannot be more than two distinct bundles of the type T_d.

The statement is straightforward when it is applied to bundles of the type T_c. There is only one bundle of this type that can be ever optimal for the monopolist to offer. This is the first-best bundle of the θ_H-type, T_h^*.

Offering the bundle T_b only makes sense when the bundle T_a is offered; otherwise, the

whole surplus of the θ_H-type can be extracted with the bundle T_c. The parameters of the bundle T_a depend on the presence of the bundle T_b. If it is not present, then the bundle T_a is the first-best bundle for the type θ_L, T_l^*. Otherwise, there is a downward distortion in the consumption level q_a. Below, I construct two cases showing that it is not optimal to offer two distinct bundles of the type T_a or T_b.

(a) Offering two bundles of the type T_b is not optimal (by contradiction).

Assume that only one bundle of the type T_a, T_a^1, and two bundles of the type T_b, T_b^1 and T_b^2, are offered. Both T_b bundles have to be incentive compatible with the bundle T_a^1 for the type θ_H: $V_{Hb^1} = V_{Hb^2} = V_{Ha^1}$. Parameters of bundles T_a and T_b do not affect the monopolist's profit from offering other types of bundles. Hence, we can look at the profit maximization problem for the bundles T_a^1, T_b^1, and T_b^2 in isolation from the profit from other bundles.

Given that $V_{Hb^1} = V_{Hb^2}$, bundles T_b^1 and T_b^2 are distinct only if $q_b^1 \neq q_b^2$. Without a loss of generality, assume that $q_b^1 > q_b^2$. Then, the choice rules are the following:

$$f(V_{La^1}, V_{Lb^1}) = f(V_{La^1}, V_{Lb^2}) = 1, \tag{3.35}$$

$$f(V_{Lb^1}, V_{La^1}) = f(V_{Lb^2}, V_{La^1}) = f(V_{Lb^2}, V_{Lb^1}) = f(V_{Lb^1}, V_{Lb^2}) = 0, \tag{3.36}$$

$$f(V_{Hb^1}, V_{Ha^1}) = f(V_{Hb^2}, V_{Ha^1}) = f(V_{Hb^1}, V_{Hb^2}) = 1, \tag{3.37}$$

$$f(V_{Ha^1}, V_{Hb^1}) = f(V_{Ha^1}, V_{Hb^2}) = f(V_{Hb^2}, V_{Hb^1}) = 0. \tag{3.38}$$

The θ_L-type never chooses bundles T_{b^1} and T_{b^2}. The choice of the θ_H-type depends on what bundles he has in his consideration set.

In this case, the monopolist's profit from offering T_a^1, T_b^1, and T_b^2 is the following:

$$
\begin{aligned}
\pi_a^{C(2)} &= \lambda(s_L^{a^1b^1} + s_L^{a^1b^2})(t_a^1 - cq_a^1) + & (3.39) \\
&+ (1-\lambda)[(s_H^{a^1b^1} + s_H^{b^1b^2})(t_b^1 - cq_b^1) + s_H^{a^1b^2}(t_b^2 - cq_b^2)] \\
t_a^1 &= u(\theta_L, q_a^1), & (3.40) \\
t_b^1 &= u(\theta_H, q_b^1) - u(\theta_H, q_a^1) + t_a^1, & (3.41) \\
t_b^2 &= u(\theta_H, q_b^2) - u(\theta_H, q_a^1) + t_a^1. & (3.42)
\end{aligned}
$$

First-order conditions with respect to q_b^1 and q_b^2 require that $u_q(\theta_H, q_b^1) = u_q(\theta_H, q_b^2) = c$. This implies that $q_b^1 = q_b^2 = q_h^{FB}$. This contradicts the assumption that $q_b^1 > q_b^2$. This, in turn, implies that if two bundles of the type T_b are offered, they are not distinct.

(b) Offering two bundles of the type T_a is not optimal (direct proof).

Assume that two bundles of the type T_a, T_a^1 and T_a^2, and one bundle of the type T_b, T_b^1, are offered. Both bundles T_a^1 and T_a^2 extract the whole suplus of the θ_L-type. Hence, to be distinct, they need to have different consumption levels. Without a loss of generality, assume that $q_a^1 > q_a^2$. Then only one of them, namely T_a^2, can be incentive compatible with T_b^1 for the θ_H-type. Optimally, T_a^1 should be the first-best bundle for the θ_L-type, T_l^*. Then the choice rules are:

$$f(V_{Ll}^*, V_{La^2}) = f(V_{Ll}^*, V_{Lb^1}) = f(V_{La^2}, V_{Lb^1}) = 1, \tag{3.43}$$

$$f(V_{La^2}, V_{Ll}^*) = f(V_{Lb^1}, V_{Ll}^*) = f(V_{Lb^1}, V_{La^2}) = 0, \tag{3.44}$$

$$f(V_{Hl}^*, V_{Ha^2}) = f(V_{Hl}^*, V_{Hb^1}) = f(V_{Hb^1}, V_{Ha^2}) = 1, \tag{3.45}$$

$$f(V_{Ha^2}, V_{Hl}^*) = f(V_{Ha^2}, V_{Hb^1}) = f(V_{Hb^1}, V_{Hl}^*) = 0. \tag{3.46}$$

This leads to the following profit for the monopolist:

$$\pi_b^{C(2)} = [\lambda(s_L^{la^2} + s_L^{lb^1}) + (1-\lambda)(s_H^{la^2} + s_H^{lb^1})]p_l^* + \lambda s_L^{a^2b}p_a^2 + (1-\lambda)s_H^{a^2b}(p_h^* - V_{Ha^2}). \tag{3.47}$$

This profit is higher than the profit from offering a single bundle T_l^* when the following condition is satisfied:

$$(\lambda s_L^{ab} + (1-\lambda)s_H^{ab})p_l^* < B, \tag{3.48}$$

$$\text{where } B = \lambda s_L^{a^2b}p_a^2 + (1-\lambda)s_H^{a^2b}(p_h^* - V_{Ha^2}). \tag{3.49}$$

The profit from offering (T_l^*, T_a^2, T_b^1) is higher than the second-best profit when the following condition is satisfied:

$$(1 - \lambda s_L^{ab} - (1-\lambda)s_H^{ab})p_l^* > \lambda p_l^{SB} + (1-\lambda)(p_h^* - V_{Hl}^{SB} - B. \tag{3.50}$$

The profit from (T_l^*, T_a^2, T_b^1) is simultaneously higher than profits from a single bundle T_l^* and the second-best offer when:

$$\lambda p_l^{SB} + (1-\lambda)(p_h^* - V_{Hl}^{SB}) < p_l^* < \frac{\lambda s_L^{a^2b}p_a^2 + (1-\lambda)s_H^{a^2b}(p_h^* - V_{Ha^2})}{\lambda s_L^{ab} + (1-\lambda)s_H^{ab}}. \tag{3.51}$$

Given that the second-best profit is at least equal to $\lambda p_a^2 + (1-\lambda)(p_h^* - V_{Ha^2})$, condition

(3.51) is impossible to satisfy. Hence, it is never optimal to offer (T_l^*, T_a^2, T_b^1) to the consumer who follows the $C(2)$ procedure. □

Lemma 3 Assume that the consumer chooses according to the $C(2)$ procedure. Only the following pricing strategies might be optimal: (1) a single bundle T_a or T_c, (2) two bundles T_a and T_b, (3) three bundles T_a, T_c, and T_d, (4) four bundles T_a, T_b, T_c, and T_d.

Proof. For the proof, I consider possible combinations of potentially optimal bundles T_a, T_b, T_c, and T_d using the result of Lemma 4 that offering two bundles of the same type is never optimal.

Single bundle: If the monopolist offers a single bundle, this bundle should extract the whole surplus of one of the consumer types, that is, he chooses between bundles T_a and T_c. To maximize the extracted surplus, the first-best level of consumption has to be provided. This leads to T_a becoming equivalent to T_l^* and T_c becoming equivalent to T_h^*.

Two bundles: The only reasonable combination of two bundles offered to $C(2)$-consumers is (T_a, T_b). If either of them is combined with another bundle, that bundle is never chosen by any consumer. Also, offering two bundles (T_c, T_d) does not bring anything in addition to offering a single bundle T_c. When two bundles (T_a, T_b) are offered, it is optimal to set them equivalent to the second-best bundles.

Three bundles: The θ_H-type chooses T_c only when he has it in the consideration set together with T_d. So, these two should be offered only together. Offering T_b and not T_c might be optimal only when T_a is offered, and the monopolist needs a bundle that would be incentive compatible with T_a for the θ_H-type. The only reasonable combination of three bundles is, hence, (T_a, T_c, T_d) such that T_a and T_c are the first-best bundles for the θ_L- and θ_H-types, correspondingly.

Four bundles: Given the result of Lemma 4, the only possibility in this case is to offer one bundle from each category. □

Proposition 2 Assume that the consumer chooses according to the $C(2)$ procedure. It is optimal for the monopolist to offer dominated bundles T_h^* and T_d **only if** the θ_H-type is more likely to have only dominated bundles in his consideration set than the θ_L-type.

Proof. The claim made in the proposition implies that $s_H^{hd} > s_L^{hd}$ when three bundles T_l^*, T_h^*, and T_d are offered, and $r_H^{hd} > r_L^{hd} + r_L^{bd} + r_L^{bh}$ when four bundles T_a, T_b, T_h^*, and T_d are offered (to distinguish these two cases, I use s_i^{jk} and r_i^{jk} for the corresponding probabilities when three or four bundles are offered). The latter is the case because T_b

is dominated for the θ_L-type. To prove the claim, I derive the necessary conditions for pricing strategies (T_l^*, T_h^*, T_d) and (T_a, T_b, T_h^*, T_d) to be optimal.

(a) The necessary condition for (T_l^*, T_h^*, T_d) to be offered.

The monopolist's profit from offering (T_l^*, T_h^*, T_d) is equal to:

$$\pi_{T_l^*, T_h^*, T_d}^{C(2)} = [\lambda(s_L^{lh} + s_L^{ld}) - (1-\lambda)(s_H^{lh} + s_H^{ld})]p_l^* + (1-\lambda)s_H^{hd}p_h^*, \qquad (3.52)$$

where $s_i^{lh} + s_i^{ld} = 1 - s_i^{hd}$. The only difference from the profit from offering (T_l^*, T_h^*) to the consumer who follows the $C(1)$ choice procedure (see equation (3.27)) is that the probability s_i^{hd} replaces the probability s_i^h. Correspondingly, the profit from offering (T_l^*, T_h^*, T_d) is higher than the profit from offering a single bundle, T_l^* or T_h^*, when the following condition holds:

$$1 - \lambda\frac{s_H^{hd} - s_L^{hd}}{s_H^{hd}} < \frac{(1-\lambda)\, p_h^*}{p_l^*} < 1 + \lambda\frac{s_H^{hd} - s_L^{hd}}{1 - s_H^{hd}}. \qquad (3.53)$$

The condition (3.53) is no longer sufficient for the offer (T_l^*, T_h^*, T_d) to be the optimal strategy because the comparison with the second-best profit is also required (see below). However, this condition allows us to see that $s_H^{hd} > s_L^{hd}$ is necessary for the offer (T_l^*, T_h^*, T_d) to be the optimal strategy. When $(1-\lambda)\, p_h^* = p_l^*$, this necessary condition also guarantees that offering (T_l^*, T_h^*, T_d) is more profitable than offering a single bundle.

To derive the sufficient condition for the dominated bundles T_h^* and T_d to be a part of the optimal pricing strategy, I compare it with the second-best profit (3.18). Taking into account conditions (3.19) and (3.20) that guarantee that offering two second-best bundles is more profitable than offering a single bundle, I get the following restriction:

$$\max\{0, p_l^* - (1-\lambda)p_h^*\} < \lambda p_l^{SB} - (1-\lambda)V_{Hl}^{SB} < \qquad (3.54)$$
$$(\lambda(1 - s_L^{hd}) + (1-\lambda)(1 - s_H^{hd}))p_l^* - (1 - s_H^{hd})(1-\lambda)p_h^*.$$

Condition (3.53) that requires the profit from (T_l^*, T_h^*, T_d) to be higher than the profit from offering a single bundle T_l^* or T_h^* is embedded in condition (3.54). Note that in the special case when $(1-\lambda)\, p_h^* = p_l^*$, the condition (3.54) transforms to the following one:

$$0 < \lambda p_l^{SB} - (1-\lambda)V_{Hl}^{SB} < \lambda p_l^*(s_H^{hd} - s_L^{hd}), \qquad (3.55)$$

which is, in general, possible to satisfy when the difference between s_H^{hd} and s_L^{hd} is large

enough. This implies that the monopolist offers (T_l^*, T_h^*, T_d) when the θ_H-type is sufficiently more likely to have bundles T_h^* and T_d in his consideration set than the θ_L-type.

(b) The necessary condition for (T_a, T_b, T_h^*, T_d) to be the optimal offered.

The monopolist's profit from offering (T_a, T_b, T_h^*, T_d) is equal to:

$$\pi_{T_a,T_b,T_h^*,T_d}^{C(2)} = (\lambda r_L^{a\cdot} + (1-\lambda)(r_H^{ah} + r_H^{ad}))p_a - (1-\lambda)r_H^{b\cdot}V_{Ha} + (1-\lambda)(r_H^{hd} + r_H^{b\cdot})p_h^*, \quad (3.56)$$

where r_i^{jk} is the probability that the θ_i-type has bundles j and k in his consideration case when four bundles are offered (to avoid confusion with s_i^{jk}, which is used when three bundles are offered), and $r_i^{j\cdot} = \sum_{\forall k \neq j} r_i^{jk}$ for $i = L, H$. The θ_L-type buys the bundle T_a when he has it in his consideration set, and buys nothing otherwise. The θ_H-type buys the bundle T_b when he has it in his consideration set, buys the bundle T_a when he has it and does not have T_b, and buys T_h^* in the remaining case. The bundle T_b has to be incentive compatible with the bundle T_a for the θ_H-type. Hence, $p_b = p_h^* - V_{Ha}$, and there is a corresponding downward distortion in q_a.

The monopolist's profit from the pricing strategy (T_a, T_b, T_h^*, T_d) is higher than his profit from offering a single bundle T_l^* or T_h^* when the corresponding inequalities are satisfied:

$$(1-\lambda)(r_H^{hd} + r_H^{b\cdot})p_h^* > p_l^* - A, \quad (3.57)$$

$$(1-\lambda)(1 - r_H^{hd} - r_H^{b\cdot})p_h^* < A, \quad (3.58)$$

$$\text{where } A = \lambda r_L^{a\cdot} + (1-\lambda)(r_H^{ah} + r_H^{ad}),$$

The monopolist's profit from the offer (T_l^{SB}, T_h^{SB}) has the following lower bound:

$$\pi^{SB} \geq \lambda p_a + (1-\lambda)[p_h^* - V_{Ha}], \quad (3.59)$$

when he offers T_a instead of T_{SB}, and hence, is not in the optimum. It follows that for the pricing scheme (T_a, T_b, T_h^*, T_d) to be more profitable than (T_l^{SB}, T_h^{SB}) at minimum, the following condition should be satisfied:

$$(1-\lambda)(1 - r_H^{hd} - r_H^{b\cdot})p_h^* < A - \lambda p_a + (1-\lambda)V_{Ha}. \quad (3.60)$$

This restriction is relevant when $\lambda p_a > (1-\lambda)V_{Ha}$, and otherwise, the monopolist is binded by the condition (3.58). Conditions (3.57), (3.58), and (3.60) together lead to the

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following:

$$\frac{p_l^* - A}{r_H^{hd} + r_H^{b.}} < (1 - \lambda)p_h^* < \frac{\min\{A, A - \lambda p_a + (1 - \lambda)V_{Ha}\}}{1 - r_H^{hd} - r_H^{b.}}. \tag{3.61}$$

From here, I get the necessary condition for the pricing strategy (T_a, T_b, T_h^*, T_d) to be more profitable than T_l^*, T_h^*, and (T_l^{SB}, T_h^{SB}). This condition is that the θ_L has dominated bundles T_b, T_h^*, and T_d in his consideration set with a lower probability than the θ_H-type has in his dominated bundles T_h^* and T_d, i.e. $1 - r_L^{a.} < r_H^{hd}$.

The sufficient condition for the pricing strategy (T_a, T_b, T_h^*, T_d) to be more profitable than T_l^*, T_h^*, and (T_l^{SB}, T_h^{SB}) is similar to condition (3.61). The difference is that p_a and V_{Ha} are replaced with p_l^{SB} and V_{Hl}^{SB} (but not inside of A). $\qquad\square$

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