Rebate Contracts and Consumer Tariff Choice:

Three Essays on Industrial Organization Theory

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Preface

The research for this doctoral thesis has been conducted at the Heinrich-Heine-University of Düsseldorf, at the Düsseldorf Institute for Competition Economics (DICE).

The thesis has profited from discussions with professors and colleagues, as well as from presentations at various national and international conferences. I am grateful to all who supported and improved my work in that way.

In particular, I would like to thank my supervisors Prof. Dr. Christian Wey and Prof. Dr. Hans-Theo Normann for many helpful comments and suggestions.

In addition, I would like to thank my co-author Anne-Kathrin Barth for the excellent collaboration and for many critical remarks, which helped me to improve this thesis. Finally, I am very grateful to my parents, my brother and Christoph Buck who patiently supported me in various ways. This dissertation is dedicated to them.

Contents

Chapter 1

Introduction

This thesis contributes to the widespread discussion on irrational behavior. It focuses on two distinct fields: the health care and the telecommunications sector. Although these sectors differ in many aspects and we use diverse methods, we find that irrational behavior plays a role in both areas. In the health care context, patients may have "feelings" about the effectiveness of drugs that are, not necessarily identical with those listed on the instruction leaflet. In the telecommunications sector, people do not always minimize costs when they are expected to do so, but are misled by doorbusters. Consequently, we contribute to the ongoing discussion on the fact that people do not behave rationally under a variety of circumstances. Thus, our findings in two very distinct research areas are also relevant for the legislator, companies and for each and every individual.

Part I of this thesis deals with rebate contracts in the health care sector. Worldwide total expenditures on pharmaceuticals and other medical non-durables are vastly increasing. In 2010, they made up 14.8 percent of total expenditures on health care in Germany, followed by 11.9 percent in the United States (OECD Health Data (2012)). As revenues do not rise in the same way, governments have taken various approaches to cut down expenditures.

One way is the implementation of rebate contracts. Generally, we distinguish between two different concepts: legally fixed rebates and voluntary ones. In the case of compulsory rebates, the manufacturers have to pay certain fixed rebates on the list prices. Alternatively, hospitals, nursing homes and other health care providing organizations may form group purchasing organizations (GPOs) and ask the manufacturers to grant discounts. Depending on their buyer power, the size of the discounts varies.

The aim of this thesis is to analyze different forms and aspects of rebate contracts. We answer the question, are rebate contracts in general appropriate methods to decrease total expenditures, both in a static and a dynamic analysis. Additionally, we present the effects of different rebate contract forms on firms' profits, consumer surplus and total welfare. By that, we show that there exists no superior rebate contract form.

Chapter 2 is entitled **The Effects of Rebate Contracts on the Health Care System** and will be published in the European Journal of Health Economics. It studies the effects of different rebate contract schemes on the health care system. GPOs increasingly gain in importance with respect to the supply of pharmaceutical products and frequently use different rebate contract schemes to exercise market power. Based on a Hotelling model, we account for horizontal and vertical product differentiation. Even when drugs have the same active ingredient and are identical from a pharmacological point of view, they may be perceived differently by the patients. This might result from effective quality differences, for example the ease of drug-taking and the coating of a pill, or from a higher perceived quality, based on effective marketing and reputation. Those aspects may conflict with the classical concept of the homo oeconomicus.

We show that different rebate contract schemes generally lower total costs when, compared to no rebate contracts, and are thus advantageous. However, analyzing different forms, we find that there exists no rebate form that per se leads to lowest total cost for the consumers or maximizes total welfare.

Chapter 3, entitled **Rebate Contracts: A Differential-Game Approach**, also analyzes rebate contracts, but in a dynamic context. We investigate the effects of rebate contracts in the health care sector, taking a differential game approach. Using dynamic duopolistic competition, we derive the open-loop, the closed-loop and the feedback solution. In the case of the open-loop solution concept, firms can account for the initial state of the world, but not for the dynamics of the system. Alternatively, firms may also consider strategic interactions through the evolution of state variables and the associated adjustment of the control variables. Hence, they solve the games either using feedback or closed-loop solution concepts.

Under the closed-loop and the feedback solution, competition is more intense than under the open-loop solution. As a consequence, prices are lowest under the closed-loop, followed by the feedback and the open-loop solution.

With increasing rebates granted, quantities in equilibrium rise, while prices net of rebates decrease. This is in contrast to static solution concepts, in which rebates do not influence equilibrium outcomes at all. In the limit, quantities and prices converge to the static perfect competition equilibrium. With rising rebates, the differences between quantities and prices in equilibrium under the three dynamic solution concepts disappear.

Part II focuses on irrational consumer choices in the context of cell phone tariff choices. Based on marketing science and behavioral economics, we detect that many consumers choose calling plans that are not cost-minimizing (e.g., Bolle and Heimel (2005) and Lambrecht and Skiera (2006)). This phenomenon is particularly prominent when consumers are asked to choose between different payment options. In general, three different tariff concepts can be distinguished: consumers may either purchase the handset immediately at contract formation (buy now option), or pay the handset price by monthly installments (hire-purchase option). The third alternative is a contract with handset subsidies, containing no or low expenditures for the handset as it is included in the relatively high cost of usage. To find out more about the main drivers for consumers' contract choice, we run an experiment with students and staff of the Heinrich-Heine-University of Düsseldorf.

Chapter 4, entitled **Experimental Evidence on Mobile Tariff Choices**, presents the findings of our experiment and is coauthored with Anne-Kathrin Barth. We investigate why consumers choose calling plans that are not cost-minimizing. Our approach is twofold: we account for general difficulties facing a tariff choice, as well as for consumers' preferences.

Our experiment is structured in three distinct parts. In the first part, respondents are asked to estimate their average monthly consumption in terms of outgoing minutes. This estimation is compared to the average usage of their last three cell phone bills. The second part of the experiment consists of 10 tariff choices and participants are asked to select one tariff out of three given tariffs. In the third part, respondents are asked to give detailed information on personal characteristics and their calling behavior.

We find that participants are often not aware of their actual consumption. However, respondents are generally able and willing to detect cost-minimizing tariffs. In addition, with rising usage level, consumers' performance improves. However, some participants hold strong preferences for certain tariff forms, deterring them from choosing cost-minimizing tariffs. We show that consumers particularly hold preferences for tariffs including subsidies and hire-purchases of cell phones.

Chapter 5 summarizes and discusses the main findings of this thesis and points to the future research agenda.

Part I

Rebate Contracts in the Health Care Market

Chapter 2

The Effects of Rebate Contracts on the Health Care System

2.1 Introduction

In the last five years, the global turnover of pharmaceuticals has steadily increased and reached 956 billion US-Dollars in 2011 (IMS Health Market Prognosis (2012)). Total expenditures on pharmaceuticals and other medical non-durables make up a significant proportion of total expenditures on health. In 2010 they constituted 14.8 percent of total expenditures on health in Germany and 11.9 percent in the United States (OECD Health Data (2012)). Innumerable attempts have been made to reduce these enormous costs.

One approach is to increase the buyer power of hospitals, nursing homes and other health care providing organizations by forming group purchasing organizations (GPOs). The importance of GPOs in the health care sector is increasing rapidly and globally. Burns and Lee (2008) find, in their empirical evaluation for the United States, that 80 percent of the hospitals in their survey make 50 percent or more of their pharmaceutical purchases via GPOs. Recently German statutory health insurance companies have also been acting like GPOs, bundling their insurants' demand and negotiating directly with pharmaceutical manufacturers.

Generally, GPOs do not purchase drugs and resell them; rather, they aggregate their members' demand and solicit bids from manufacturers. To reduce costs, supply contracts, typically including rebates, are conducted with one or more firms, and the members of the GPOs are able to purchase at the prices and other terms specified in the contracts. Depending on the number of affiliates and the possibility to buy off-contract, three regimes have to be distinguished: multiple, exclusive and partially exclusive rebate contracts. It is up to the GPOs whether they conclude rebate contracts with all horizontally differentiated manufacturers (multiple rebate contracts) or exclusively with one of them (exclusive rebate contracts). Hybrid forms are referred to as partially exclusive rebate contracts. In these cases, the GPOs conduct rebate contracts with one of the manufactures; however, the members of the GPOs are not obliged to buy the pharmaceutical products under the terms of the rebate contract, but have the possibility to buy off-contract. Therefore, they can still choose between all manufacturers, which ensures maximum product variety, but potentially forgo rebates.

Partially exclusive rebate contracts correspond to the situation in Germany after the Act for Restructuring the Drug Market (Arzneimittelneuordnungsgesetz, AMNOG) came into effect on 1 January 2011. Before that, members of statutory health insurance companies were bound to the exclusive rebate contracts of their insurance companies. Consequently, some insurants were obliged to change their pharmaceutical products. With the Act for Restructuring the Drug Market (Arzneimittelneuordnungsgesetz, AMNOG), patients are now able to maintain their usual drugs. However, they have to pay any price differences to the substitute in the rebate contract themselves.

There also exists a trend to restrict consumers' choice, which can, for example, be found when analyzing the behavior of HMOs in the United States acting like GPOs. Roughly 100 million Americans are covered by the 38 Blue Cross and Blue Shield companies (Blue Cross and Blue Shield Companies (2013)). Every Blue Cross and Blue Shield company develops a prescription drug list, which is updated regularly. Criteria for drugs to be included in the prescription drug list are the safety, effectiveness and cost of the drug (e.g., Blue Cross and Blue Shield of Illinois - Drug Formulary (2013)). It restricts the choice of members at lower copayment levels to the listed prescription drugs, meaning drugs not listed are only available at a higher copayment.

Besides horizontal differentiation based on individual preferences, pharmaceutical products are also vertically differentiated. Although from a chemical point of view the drugs are identical, they may however differ in quality. On the one hand, these quality differences may manifest in different sizes, routes of administration or side effects. On the other hand, certain drugs have a higher perceived quality due to effective marketing and reputation.

Horizontal as well as vertical differentiations are often not taken into consideration by the GPOs acting as intermediary between their members and pharmaceutical manufacturers. They minimize expenditures and hence their sole decision variables are unit prices, possibly net of rebates. Depending on the magnitude of differentiation, the GPOs are likely to opt for a rebate scheme that is not in the interest of their members.

The aim of this chapter is to investigate the impacts of three rebate contract forms: multiple, exclusive and partially exclusive rebate contracts. We answer the question whether there is a rebate form that is superior as far as consumer surplus, firms' profits and total welfare are concerned. Additionally, we address potential delegation problems between the GPOs and their members due to differences between total costs and total expenditures.

We show that multiple rebate contracts lower total costs for the members of the GPOs and exclusive rebate contracts leave them unaffected compared to no rebate contracts. Consequently, both rebate forms are advantageous.

Considering quality differences, only exclusive rebate contracts with the high-quality manufacturer are favorable, independent of quality differences. Total costs for exclusive rebate contracts with the low-quality manufacturer, multiple rebate contracts and partially exclusive rebate contracts depend on quality differences. For sufficiently significant quality differences, exclusive rebate contracts with the low-quality manufacturer yield highest aggregated costs. We also find that it never reduces costs for the members of the GPOs to conduct partially exclusive rebate contracts instead of exclusive rebate contracts with the high-quality manufacturer. Regarding rebate contracts with the low-quality firm, the favorability between partially exclusive and exclusive rebate contracts depends on quality differences.

Manufacturers, on the other hand, can increase their profits via partially exclusive rebate contracts compared to multiple and exclusive rebate contracts. They both prefer partially exclusive over multiple, and multiple over exclusive rebate contracts.

As well as total cost, total welfare also depends on the degree of differentiation. For rather small quality differences, partially exclusive rebate contracts are superior to exclusive rebate contracts, and multiple rebate contracts lead to the highest welfare. With increasing quality differences, exclusive rebate contracts gain in attractivity, while multiple rebate contracts lose.

We also find that delegation problems may arise as the GPOs are likely to opt for exclusive rebate contracts irrespective of the affiliate, while the members of the GPOs evaluate exclusive rebate contracts with high- or low-quality firms differently. Furthermore, based on expenditures, the GPOs are likely to ignore the advantages of partially exclusive rebate contracts.

The rest of the chapter is organized as follows: Chapter 2.2 introduces related literature. In chapter 2.3, we present the underlying model of horizontal differentiation, including the specifications of the different rebate schemes. In chapter 2.4, we analyze the benchmark cases before the introduction of rebate contracts. Focusing on the three different rebate schemes, in chapter 2.5 we present total costs and expenditures for the consumers, firms' profits and total welfare. In part 2.6, we set up a ranking of the different rebate schemes depending on quality differences. Finally, chapter 2.7 explores the robustness of the results by discussing some of the main assumptions of the chapter and by providing concluding remarks as well.

2.2 Related Literature

To date there is a vast body of empirical surveys regarding GPOs and rebate contracts, including the articles from Burns and Lee (2008), Kolasky (2009), Schneller (2009), and Ellison and Snyder (2001). Based on empirical findings, they point to price reductions and efficiency gains due to rebate contracts. Publications by Hovenkamp (2002), Elhauge (2002) and Lindsay (2009) focus on legal aspects of GPOs and discounts. Many theoretical and empirical studies investigate how GPOs enhance buyer power (e.g., Snyder (1998), Dana (2006), Inderst and Wey (2007), and Tyagi (2001)), but none of these works evaluates different forms of rebate contracts. Hence, this article is, to the best of our knowledge, the first that provides a theoretical model dealing with GPOs and alternative discount forms, taking also quality differences into consideration.

Our article relates to several research streams, including rebate contracts and quality differences. The rebates in our model are specified as all-units discounts, which are common for a health care setup and also used by Kolay et al. (2004) and Greenlee et al. (2008), revealing ambiguous results concerning the effects of rebate contracts on consumer surplus and total welfare. Nevertheless, neither of these two articles considers the specific role of GPOs and different rebate schemes, which are a central aspect of this paper. Chen and Roma (2001) study GPOs in a setup with two retailers and one manufacturer, offering all-units discounts. They show that under linear demand curves, symmetric retailers always profit from rebate contracts conducted via GPOs. In our model, we assume the buyers to be consumers, either insurants, hospitals or health care-providing organizations, and we do not consider a single manufacturer but two competing firms at the upstream level. However, we also find that under most circumstances rebate contracts, irrespective of the concrete design, are advantageous for the members of the GPOs. Therefore, our findings are also in line with Marvel and Yang (2008), who argue that loyalty discounts lead to far more competitive outcomes than Bertrand-Nash competition with linear tariffs, lowering total costs for the consumers. The model of Marvel and Yang (2008) also deals with rebate contracts in a health care context and, as we do, they use the model of horizontal differentiation by Hotelling (1929). In their model, the GPOs offer the manufacturers the possibility of implementing rebate contracts, and thus they generate allocative efficiencies. However, contrary to their setup, we assume a functional form of the rebate contracts and evaluate the impact of alternative discount forms.

Additionally, we also account for quality differences. Especially in the health care context, quality differences have to be taken into account. One of the first to analyze quality differences in a Hotelling setup was Weizsäcker (1984). He developed a model consisting of two firms competing for consumers, with differences in the quality of their products. Consumers' decisions to switch manufacturer depend on their relative position to the suppliers, which can change over time. This very general setup has been enriched by health care-specific factors in various articles. Schlesinger and Schulenburg (1991) model quality differences explicitly, but compared to search costs. Quality differences are also covered by Brekke et al. (2006), Miraldo (2008), and Hu and Schwarz (2011) and specified in a very similar way to our approach. In contrast to our article, Brekke et al. (2006) and Miraldo (2008) cover quality differences in the context of reference pricing, and Hu and Schwarz (2011) consider quality differences in combination with contract administration fees that GPOs might demand from manufacturers.

Based on the combination of rebate contracts and quality differences, our article also provides a theoretical model for the evidence-based discussion on the harms and benefits of rebate contracts. As far as Germany is concerned, for example, before the introduction of the Act for Restructuring the Drug Market (Arzneimittelneuordnungsgesetz, AMNOG) in 2011, exclusive rebate contracts did not include the option to buy off-contract. Consequently, they may have forced patients to substitute their drugs. Leutgeb et al. (2009) find in their study that about 52 percent of the patients who have to substitute their drugs feel unsure and about 20 percent face difficulties taking different drugs. Thus, by evaluating the impact of different rebate contract schemes, we provide possible policy conclusions for Germany and beyond, and contribute to the growing body of literature on health care issues.

2.3 Model

2.3.1 Setup

Drugs for the treatment of one particular disease are assumed to be horizontally differentiated goods. Although they have the same main ingredient, consumers hold different preferences. The importance of differentiated preferences may vary between consumers, depending on personal characteristics. To incorporate this, and in line with the existing literature, we base our setup on a standard Hotelling model of horizontal differentiation. Two manufacturers, 1 and 2, are located at the opposite ends of a unit interval. The consumers, being either hospitals, health care-providing organizations or individual insurants of a unity mass, are distributed uniformly along this line. All these consumers are members of one GPO.

Consuming a certain type of drug from firm 1 or 2 provides each member of the GPO with a basic constant utility of V, reduced by the prices they have to pay and the possible mismatch between the real and their ideal product. Prices are paid directly to the pharmaceutical firms. Additionally to the unit prices, the utility is also reduced by linear transportation costs. Transportation costs reflect consumers' preferences for certain drugs and thus the fact that they are not perceived as homogeneous goods.

On top of that, drugs often not only differ horizontally, but also vertically. We suppose there is a quality difference of β between the competitors. This might, on the one hand, result from effective quality differences such as the ease of drug-taking and the coating of a pill. On the other hand, certain drugs might have a higher perceived quality because of effective marketing and reputation. Very often these quality differences also have a temporal component. Being the first to introduce a new product often guarantees the manufacturer the ability to create long-lasting consumer relations, leading to entry barriers favoring the incumbent. All consumers perceive manufacturer 1 as offering the high-quality drug and firm 2 as offering a pharmaceutical product of lower quality. To insure positive quantities in equilibrium, β is implemented as $0 < \beta < 3t - r$.

The members of the GPO have delegated the decision-making power to the GPO. However, in contrast to the members of the GPO, the GPO might not be able or willing to account for non-monetary costs caused by differentiation. This may be due to heterogeneous preferences, depending, for example, on the age of the consumers. Even in the case of homogeneous preferences, data on patients' preferences may be missing or only available at high cost. As consumers' willingness to change the GPO is rather low in the health care context, the pressure on the GPO to take all costs into consideration is moderate. Consequently, the GPO is assumed not to minimize total costs of the consumers, but rather to minimize total expenditures and to take prices as the sole decision variable when it chooses the contract partner.

As far as the number of firms serving the market is concerned, two alternative contract systems are possible: either one or two firms may be active. Generally, there are no legal constraints, and the GPO is free to choose between both alternatives.

Typically, the GPO aggregates its members' demand and thus possesses bargaining power. As a result, it not only informs its members about prices and quantities, but also actively influences market outcomes. One alternative is to ask the affiliates to grant rebates. Where a manufacturer wants to be listed by the GPO and thus available for the members of the GPO, it has to grant discounts. Within these rebate contract systems there are various possibilities for a GPO to exercise market power. The most common ones in the context of rebate contracts are exclusive rebate contracts and multiple rebate contracts.

Table 2.1 illustrates the four cases that have to be distinguished depending on the number of affiliates and whether rebates are granted.

Table 2.1: Possible Regimes

	One firm serves the market	**Two firms serve the market**
No rebate contracts	Exclusive Contracts (EC)	Multiple Contracts (MC)
Rebate contracts	Exclusive Rebate Contracts (ER)	Multiple Rebate Contracts (MR)

There also exists a third, hybrid form: partially exclusive rebate contracts. In the case of partially exclusive rebate contracts, the GPO conducts a rebate contract with one of the firms, but both of them are able to serve the market. However, buying from the firm offering off-contract products means there are no discounts for the members of the GPO.

2.3.2 Rebate Schemes

Different concepts of rebate contracts have to be distinguished. There are legally fixed rebates and even more common voluntary ones. Compulsory discounts are, for example, rebates of up to 16 percent on the list prices, as manufacturers in Germany have to grant them (Bundesministerium für Gesundheit (2012)). Alternatively, a GPO can demand certain fixed volume discounts from their suppliers, potentially also in combination with a cash discount for prompt payment. The discounts may vary depending on the size and the bargaining power of the GPO. In Germany, statutory health insurance companies, acting like GPOs, demand a minimum rebate on the list price, which pharmaceutical companies have to offer if they want to be considered as suppliers.

Rebate contracts are typically given in the form of all-units discounts. Even though each member of the GPO is assumed to buy at most one unit, it may receive a volume discount. There are no individual rebates on the basis of each member, but discounts are accorded to the GPO for all its members. The GPO, not accounting for transportation costs, does not differentiate between its members according to their marginality. Consequently, it distributes the rebates between all members buying from the same firm. We assume that rebates are spread evenly among all buyers, and thus to derive individual discounts, total rebates have to be divided by the number of consumers buying their product from the same manufacturer.

In order to incorporate best the idea of individual rebates depending on collective decisions, polynomial all-units discounts are implemented. Another advantage of rebates of the form $R(x) := rx^m$, with $m > 1$ and $x \in [0, 1]$ being the total quantity bought from one of the two manufacturers is that they reflect the concept of economies of scale. Development and production costs of pharmaceutical products decrease with increasing sale volumes. Therefore, manufacturers typically do not offer constant discounts; instead, they offer significantly higher ones for larger volumes.

Total rebates are specified as $R(x) := rx^2$, with r being either legally fixed or set by the GPO. It is assumed to be constant, identical for both firms, independent of quantity, and $r < t$, with tx being linear transportation costs, holds to insure positive quantities in equilibrium.

The timing of the game is as follows: first the GPO announces publicly whether it asks the firms to grant rebates or not. This may either be a firm-specific decision or result from legal obligations. In both cases firms will accept the need to offer rebates, as they are either legally obliged to do so or they want to be considered as an affiliate and earn non-negative profits. Secondly, the GPO decides whether one or two firms will serve the market. Opting for multiple contracts, both manufacturers are accepted as contract partners and set their prices. In order to increase total and individual discounts, the GPO can restrict consumers' choices to one of the firms and conduct exclusive or partially exclusive contracts. In the case of exclusive or partially exclusive rebate contracts, the two manufacturers make simultaneous take-it-or-leave-it offers to the GPO. The GPO minimizes expenditures and hence accepts the firm offering the lowest prices. Where the prices are identical, we assume that it chooses manufacturer 1.

In the following chapters, we further investigate the different outcomes depending on the number of affiliates and whether rebates are offered. We focus on whether a regime exists that is superior, yielding the lowest total costs for the consumers or highest profits for the firms.

2.4 No Rebate Contracts

First, we analyze the situation under no rebate contracts accounting for horizontal and vertical differentiation. Both contract forms are taken as benchmarks to answer the question whether the introduction of rebates lowers total cost for the members of the GPO or increases firms' profits.

2.4.1 Multiple Contracts

In the case of multiple contracts, the utility of a consumer located at position x, buying from manufacturer 1 or 2 is given by

$$U_1^{MC}(x) := V - p_1 - tx$$

or by

$$U_2^{MC}(x) := V - p_2 - t(1 - x) - \beta$$

with tx accounting for transportation costs and β for quality differences. Total consumer surplus (CS) is defined by

$$CS_{MC} = \int_0^x V - (p_1 + t\epsilon)d\epsilon + \int_0^{1-x} V - (p_2 + t\epsilon + \beta)d\epsilon$$

and equivalently total cost (C) for the consumers by

$$C_{MC} = \int_0^x (p_1 + t\epsilon)d\epsilon + \int_0^{1-x} (p_2 + t\epsilon + \beta)d\epsilon.$$

We assume that the distribution of the consumers is common knowledge but the manufacturers are unable to identify individual preferences. This limited information prevents firms from price discrimination. Hence, the demand functions are given by

$$D_1^{MC}(p_1, p_2) = \begin{cases} 1 & \text{if} \quad p_2 - p_1 \geq t - \beta \\ \frac{p_2 - p_1 + t + \beta}{2t} & \text{if} \quad -\beta - t \leq p_2 - p_1 \leq t - \beta \\ 0 & \text{if} \quad p_2 - p_1 \leq -\beta - t \end{cases}$$

and

$$D_2^{MC}(p_1, p_2) = \begin{cases} 1 & \text{if} \quad p_1 - p_2 \geq t + \beta \\ \frac{p_1 - p_2 + t - \beta}{2t} & \text{if} \quad \beta - t \leq p_1 - p_2 \leq t + \beta \\ 0 & \text{if} \quad p_1 - p_2 \leq \beta - t. \end{cases}$$

The two firms produce with identical marginal cost $c > 0$.[1] Thus, both manufacturers maximize profits of $\pi_1^{MC} = (p_1 - c)D_1(p_1, p_2)$ and $\pi_2^{MC} = (p_2 - c)D_2(p_1, p_2)$.

Simultaneous maximization of firms' profits leads to equilibrium prices of $p_2^{MC} = c + t - \frac{\beta}{3} < c + t + \frac{\beta}{3} = p_1^{MC}$ and the position of the indifferent consumer at $0.5 + \frac{\beta}{6t}$.

Quality differences constitute a competitive advantage for firm 1, leading to higher prices compared to the prices in the standard Hotelling model. Manufacturer 2, on the other hand, has to overcome the disadvantage of quality differences by lowering its prices compared to prices in the standard Hotelling setup. Rising quality differences widen this competitive gap even further. Due to quality differences, the number of consumers who decide to buy from manufacturer 2 is relatively small in equilibrium, and the position of the indifferent consumer is

[1] We assume identical linear production costs. All the results we present are robust to a change in production costs as long as both firms' production cost functions are identical, which is likely in the health care context.

shifted in favor of manufacturer 1.

Firms' profits are given by $\pi_2^{MC} = \frac{(3t-\beta)^2}{18t} < \frac{(3t+\beta)^2}{18t} = \pi_1^{MC}$. Manufacturer 2 loses profits because of negative effects on prices and quantities, while firm 1 benefits from quality differences and can increase profits compared to the standard Hotelling model.

The position of the indifferent consumer and prices in equilibrium lead to total costs incurred by consumers of $C_{MC} = c + 1.25t + 0.5\beta - \frac{\beta^2}{36t}$. The members of the GPO are attached to manufacturer 1, allowing manufacturer 1 to exploit his competitive advantage. Overall costs include expenditures for purchasing the pharmaceutical product and transportation costs caused by possible mismatches. The GPO, on the other hand, takes neither horizontal nor vertical differentiation into account, and it minimizes expenditures, which are given by $E_{MC} = c + t + \frac{\beta^2}{9t}$.

2.4.2 Exclusive Contracts

The GPO can also tender exclusive contracts. The manufacturer offering the lowest price is accepted as affiliate and serves the whole market. When exclusive contracts are in place, not being accepted as a rebate partner is equivalent to market exclusion. With firms anticipating this, they hand in the lowest possible price that guarantees them non-negative profits. We assume, without loss of generality, that the whole market is served by firm 1, setting the lowest possible equilibrium price of $p_1^{EC} = c$. Hence, both firms are left with zero profits, while total expenditures are given by $E_{EC1} = c$.

The members of the GPO also consider differentiation and thus incur total costs of $C_{EC1} = c + 0.5t$ in the case of exclusive contracts with manufacturer 1 and $C_{EC2} = c + 0.5t + \beta$ under exclusive contracts with firm 2.

Taking these results as the benchmark, the GPO can conduct different forms of rebate contracts to reduce its members' costs.

2.5 Rebate Contracts

2.5.1 Multiple Rebate Contracts

In the case of multiple rebate contracts, the GPO admits both manufacturers. This ensures that every member is offered their favorite type of pharmaceutical product and consequently maximum product variety. Manufacturers are asked to grant all-units discounts and thus considered when both firms simultaneously maximize their profits.

Compared to the findings in the benchmark case, presented in chapter 2.4.1, the introduction of multiple rebate contracts affects equilibrium outcomes. For the indifferent consumer located at position x

$$V - p_1 - tx + \frac{rx^2}{x} = V - p_2 - t(1-x) + \frac{r(1-x)^2}{(1-x)} - \beta$$

has to hold as consumers profit from equally shared rebates. Rebates reduce the transportation cost for the individual consumer. The modified demand functions are given by

$$D_1^{MR}(p_1, p_2) = \begin{cases} 1 & \text{if} \quad p_2 - p_1 \geq t - r - \beta \\ \frac{p_2 - p_1 + t + \beta - r}{2t - 2r} & \text{if} \quad r - t - \beta \leq p_2 - p_1 \leq t - r - \beta \\ 0 & \text{if} \quad p_2 - p_1 \leq r - t - \beta \end{cases}$$

and

$$D_2^{MR}(p_1, p_2) = \begin{cases} 1 & \text{if} \quad p_1 - p_2 \geq t - r + \beta \\ \frac{p_1 - p_2 + t - \beta - r}{2t - 2r} & \text{if} \quad r - t + \beta \leq p_1 - p_2 \leq t - r + \beta \\ 0 & \text{if} \quad p_1 - p_2 \leq r - t + \beta. \end{cases}$$

Based on the demand functions, both manufacturers simultaneously maximize profits of $\pi_1^{MR} = (p_1 - c)D_1(p_1, p_2) - r(D_1(p_1, p_2))^2$ and $\pi_2^{MR} = (p_2 - c)D_2(p_1, p_2) - r(D_2(p_1, p_2))^2$, taking total costs for the quadratic discounts into consideration. This leads to prices in equilibrium of $p_2^{MR} = c + t - \frac{t\beta}{3t-r} < c + t + \frac{t\beta}{3t-r} = p_1^{MR}$.[2] With multiple rebate contracts, the discounts

[2]Proof can be found in the Appendix at the end of this chapter.

granted depend on the consumer basis of the manufacturers. More members of the GPO buy from firm 1 than from manufacturer 2, making firm 1 more attractive as far as rebates are concerned. Firm 1 profits from this additional competitive advantage and increases prices compared to the benchmark case. Manufacturer 2, on the other hand, lowers its prices in order to compensate consumers for the rebate loss they incur. The position of the indifferent consumer is shifted in favor of manufacturer 1, compared to multiple contracts, to $0.5 + \frac{\beta}{2(3t-r)}$.

Based on prices in equilibrium and the position of the indifferent consumer, manufacturers 1 and 2 realize profits of $\pi_2^{MR} = \frac{(2t-r)(r-3t+\beta)^2}{4(r-3t)^2} < \frac{(2t-r)(3t-r+\beta)^2}{4(r-3t)^2} = \pi_1^{MR}$. Under multiple rebate contracts, firm 2's profits are smaller than those of manufacturer 1 because of lower prices and a lower consumer base.

Accounting also for quality differences, overall costs C_{MR} the members of the GPO incur are given by

$$\begin{aligned} C_{MR} &= \int_0^x (p_1 + t\epsilon)d\epsilon - rx^2 + \int_0^{1-x} (p_2 + t\epsilon + \beta)d\epsilon - r(1-x)^2 \\ &= \frac{1}{4}\left(4c - 2r + 5t + 2\beta - \frac{t\beta^2}{(r-3t)^2}\right). \end{aligned}$$

The corresponding total expenditures amount to $E_{MR} = c - 0.5r + t - \frac{(r-2t)\beta^2}{2(r-3t)^2}$.

2.5.2 Exclusive Rebate Contracts

On the other hand, the GPO can commit to exclusive rebate contracts with one of the manufacturers. For the GPO, prices are the single decision variable, and it will, in any scenario, opt for the manufacturer offering the lower price. Equivalently to exclusive contracts, manufacturer 1 is assumed to serve the whole market offering prices of $p_1^{ER} = c + r$, leading to total expenditures of $E_{ER1} = c$. For $p_1^{ER} = c + r$ manufacturer 2 has no incentive to undercut firm 1's offer as it would lead to negative profits. Hence, both firms are again left with the lowest possible profit of zero.

The members of the GPO have delegated the choice of the affiliate to the GPO. From their point of view, conducting exclusive rebate contracts with firm 1 yields total costs of $C_{ER1} = c + 0.5t$. In the case of exclusive rebate contracts with manufacturer 2, total costs are given by $C_{ER2} = c + 0.5t + \beta$. Not taking quality differences into consideration causes higher total cost for the members of the GPO, to the amount of β.

2.5.3 Partially Exclusive Rebate Contracts

In theory as well as in practice there exists a third alternative: partially exclusive rebate contracts. In the case of partially exclusive rebate contracts, the GPO conducts rebate contracts with one of the manufacturers. However, the members of the GPO are not obliged to buy the pharmaceutical product under contract; they can also purchase goods off-contract. However, buying from the firm offering off-contract products involves no discounts. The degree to which the members of the GPO buy the contracted drug is called compliance. Generally, two cases have to be distinguished: partially exclusive rebate contracts with manufacturer 1 or 2.

In the case of partially exclusive rebate contracts with manufacturer 1, the net utilities for a consumer located at position x are given by

$$U_1^{PER1}(x) := V - p_1 - tx + rx$$

and

$$U_2^{PER1}(x) := V - p_2 - t(1-x) - \beta.$$

Therefore, in equilibrium prices are given by $p_1^{PER1} = \frac{c(r-6t)+(r+2t)(r-3t-\beta)}{r-6t}$ and $p_2^{PER1} = \frac{c(r-6t)+(r-2t)(3t-\beta)}{r-6t}$ and the indifferent consumer is located at $\frac{3t+\beta-r}{6t-r}$. Manufacturers' profits in equilibrium are $\pi_1^{PER1} = \frac{2t(3t-r+\beta)^2}{(r-6t)^2}$ and $\pi_2^{PER1} = \frac{(2t-r)(\beta-3t)^2}{(r-6t)^2}$. The aggregated costs of the members of the GPO amount to

$$\begin{aligned} C_{PER1} &= \int_0^x (p_1 + t\epsilon)d\epsilon - rx^2 + \int_0^{1-x} (p_2 + t\epsilon + \beta)d\epsilon \\ &= \frac{2c(r-6t)^2 + t\left(5r^2 + 90t^2 + 36t\beta - 2\beta^2 - 4r(12t+\beta)\right)}{2(r-6t)^2}. \end{aligned}$$

The corresponding total expenditures are given by $E_{PER1} = \frac{c(r-6t)^2+2r^2t+4t\left(9t^2+\beta^2\right)-r\left(21t^2-2t\beta+\beta^2\right)}{(r-6t)^2}$. On the other hand, the GPO can also opt for partially exclusive rebate contracts with firm 2. This changes the corresponding net utilities to

$$U_1^{PER2}(x) := V - p_1 - tx$$

and

$$U_2^{PER2}(x) := V - p_2 - t(1-x) + r(1-x) - \beta.$$

Simultaneous maximization of firms' profits leads to prices in equilibrium of $p_1^{PER2} = \frac{c(r-6t)+(r-2t)(3t+\beta)}{r-6t}$ and $p_2^{PER2} = \frac{c(r-6t)+(r+2t)(r-3t+\beta)}{r-6t}$, with the indifferent consumer at $\frac{3t+\beta}{6t-r}$. Firms' profits are $\pi_1^{PER2} = \frac{(2t-r)(3t+\beta)^2}{(r-6t)^2}$ and $\pi_2^{PER2} = \frac{2t(r-3t+\beta)^2}{(r-6t)^2}$. Prices and quantities in equilibrium cause total costs of

$$\begin{aligned} C_{PER2} &= \int_0^x (p_1 + t\epsilon)d\epsilon + \int_0^{1-x} (p_2 + t\epsilon + \beta)d\epsilon - r(1-x)^2 \\ &= \frac{2c(r-6t)^2 + r^2(5t+2\beta) - 4rt(12t+5\beta) + 2t\left(45t^2 + 18t\beta - \beta^2\right)}{2(r-6t)^2}. \end{aligned}$$

and total expenditures of $E_{PER2} = \frac{c(r-6t)^2+2r^2t+4t\left(9t^2+\beta^2\right)-r\left(21t^2+2t\beta+\beta^2\right)}{(r-6t)^2}$.

For both alternatives we find that there is no complete compliance. For each opportunity, some members of the GPO decide to buy off-contract.

2.6 Comparison of the Rebate Schemes

Evaluating the alternative rebate concepts, we find that the introduction of rebate contracts lowers total costs where two firms serve the market. Where one firm serves the market, rebates do not affect total costs for the consumers, irrespective of the affiliate.

Comparing the findings regarding multiple, exclusive and partially exclusive rebate contracts, two cases have to be distinguished: The perception of the members of the GPO based on total costs and the view of the GPO based on expenditures.

Proposition 1. *From the point of view of* ***the members of the GPO*** *the ranking of the different rebate contract forms is given by:*

i) For $0 < \beta < \frac{-(r-3t)^2+\sqrt{(r-6t)(r-3t)^2(r-2t)}}{t}$: $C_{ER1} < C_{ER2} < C_{MR} < C_{PER2} < C_{PER1}$.

ii) For $\frac{-(r-3t)^2+\sqrt{(r-6t)(r-3t)^2(r-2t)}}{t} < \beta < r + \sqrt{3}\sqrt{(r-6t)^2} - 9t$: $C_{ER1} < C_{MR} < C_{ER2} < C_{PER2} < C_{PER1}$.

iii) For $r + \sqrt{3}\sqrt{(r-6t)^2} - 9t < \beta < \frac{-r^2+\sqrt{(r-6t)^3(r-2t)}+10rt-18t^2}{2t}$: $C_{ER1} < C_{MR} < C_{PER2} < C_{ER2} < C_{PER1}$.

iv) For $\frac{-r^2+\sqrt{(r-6t)^3(r-2t)}+10rt-18t^2}{2t} < \beta$: $C_{ER1} < C_{MR} < C_{PER2} < C_{PER1} < C_{ER2}$.

Irrespective of quality differences, exclusive rebate contracts with manufacturer 1 always yield the lowest total costs. Negotiating with firm 1, it is cost minimizing for the members of the GPO to opt for exclusive rebate contracts instead of partially exclusive rebate contracts, irrespective of quality differences. The reason for this is twofold; under partially exclusive rebate contracts, total rebates are strictly lower than under exclusive rebate contracts, as complete compliance is not realized. Additionally, firm 1 charges higher prices under partially exclusive rebate contracts than under exclusive rebate contracts.

For quality differences smaller than $r + \sqrt{3}\sqrt{(r-6t)^2} - 9t$ this holds true also for rebate contracts with manufacturer 2. For sufficiently large quality differences, it is cost minimizing to opt for the moderate form of partially exclusive rebate contracts.

Comparing partially exclusive rebate contracts, it minimizes total costs to select the low-quality firm, manufacturer 2, as a rebate partner. Being a partner, firm 1 profits from the possibility of granting rebates and the quality advantage. Both aspects render manufacturer 1 more attractive than firm 2 and make it charge rather high prices. When it is not selected, firm 1 decreases prices to compensate the members of the GPO for the rebate loss. Firm 2 can increases prices only moderately, making partially exclusive rebate contracts with the low-quality firm more attractive. Allowing both firms to be active in the market, that is multiple rebate contracts, guarantees fairly moderate total costs for all possible values of β.

The GPO assumes the ranking to be different, as it does not incorporate horizontal or vertical differentiation.

Proposition 2. *From the point of view of* ***the GPO*** *the ranking of the different rebate contract forms is given by:* $E_{ER1} = E_{ER2} < E_{MR} < E_{PER2} < E_{PER1} \quad \forall\beta.$

The evaluation of the members of the GPO and the GPO itself differs. The GPO is likely to opt for the cost-minimizing alternative of exclusive rebate contracts, irrespective of the manufacturer. In the case of exclusive rebate contracts with firm 1, this is in line with the choice of the members of the GPO. However, exclusive rebate contracts with manufacturer 2 yield strictly higher total costs. Partially exclusive rebate contracts cause strictly higher total expenditures than exclusive rebate contracts, irrespective of the rebate partner. Considering total cost, this only holds true in the case of rebate contracts with firm 1. These different evaluations may give rise to possible delegation problems.

Furthermore, we analyze the impact of the different rebate contract forms on firms' profits.

Proposition 3. *The ranking of firms' profits partially depends on quality differences:*

i) For manufacturer 1 it depends on β *and is given by:*

- *For* $\beta < \sqrt{4t^2 - 2rt} - t : \pi_1^{ER1} = \pi_1^{ER2} < \pi_1^{MR} < \pi_1^{PER1} < \pi_1^{PER2}.$
- *For* $\sqrt{4t^2 - 2rt} - t < \beta : \pi_1^{ER1} = \pi_1^{ER2} < \pi_1^{MR} < \pi_1^{PER2} < \pi_1^{PER1}.$

ii) For firm 2, it is given by: $\pi_2^{ER2} = \pi_2^{ER1} < \pi_2^{MR} < \pi_2^{PER2} < \pi_2^{PER1} \quad \forall\beta.$

Both manufacturers profit from partially exclusive rebate contracts, as they lead to higher profits than exclusive rebate contracts or multiple rebate contracts. For sufficiently small quality differences, manufacturer 1 profits from partially exclusive rebate contracts with manufacturer 2. The same holds true for firm 2 irrespective of quality differences. This is due to the fact that not being a partner of partially exclusive rebate contracts still guarantees positive quantities without the obligation to grant rebates. For increasing quality differences, manufacturer 1 prefers being a partner of partially exclusive rebate contracts, instead of partially exclusive rebate contracts with manufacturer 2.

In order to fully evaluate the effects of the different rebate contract forms on total costs for the members of the GPO and on firms' profits, we introduce total welfare as an additional decision variable. Total welfare adds up consumer surplus and profits of the two manufacturers for all possible rebate contract forms, while M stands for the specific rebate contract:

$$W_M = V - C_M + \pi_1^M + \pi_2^M.$$

Comparing the total welfare for all five possible regimes gives a ranking of the different rebate contract forms of:

Proposition 4. *The welfare ranking of the different rebate contract forms depends on quality differences:*

(i) For $0 < \beta < \frac{(3t-r)rt}{2r^2-15rt+24t^2}$: $W_{ER2} < W_{ER1} < W_{PER1} < W_{PER2} < W_{MR}$.

(ii) For $\frac{(3t-r)rt}{2r^2-15rt+24t^2} < \beta < \frac{(r-3t)t}{r-5t}$: $W_{ER2} < W_{ER1} < W_{PER1} < W_{MR} < W_{PER2}$.

(iii) For $\frac{(r-3t)t}{r-5t} < \beta < \frac{(r-3t)t}{2r-5t}$: $W_{ER2} < W_{PER1} < W_{ER1} < W_{MR} < W_{PER2}$.

(iv) For $\frac{(r-3t)t}{2r-5t} < \beta < \frac{3t^2}{5t-r}$: $W_{ER2} < W_{PER1} < W_{MR} < W_{ER1} < W_{PER2}$.

(v) For $\frac{3t^2}{5t-r} < \beta$: $W_{ER2} < W_{PER1} < W_{MR} < W_{PER2} < W_{ER1}$.

From a welfare perspective, exclusive rebate contracts with manufacturer 2 yield the lowest welfare, irrespective of quality differences. Both manufacturers realize zero profits and members of the GPO have to purchase the product of lower quality. Driven by lower total costs, partially exclusive rebate contracts with manufacturer 2 are superior to exclusive rebate contracts with firm 2. For sufficiently small quality differences, this also holds for rebate contracts with manufacturer 1. Although both firms constantly realize zero profits, total welfare from exclusive rebate contracts with firm 1 increases with rising quality differences because of the comparative advantage from the lowest total cost for the consumers.

2.7 Conclusion

In this chapter we analyze the effects of different rebate contract forms on consumer surplus, firms' profits and total welfare. We answer the question whether a rebate form exists that is superior under horizontal and vertical differentiation.

According to the number of rebate contract partners, we differentiate between exclusive (one affiliate) and multiple (two affiliates) rebate contracts.

Partially exclusive rebate contracts constitute a third, hybrid alternative, with the GPOs conducting rebate contracts with one of the manufacturers. However, consumers are not obliged to buy the pharmaceutical product under contract, although by not doing so they possibly forgo rebates.

Taking vertical differentiation into account as well, neither multiple nor exclusive nor partially exclusive rebate contracts are favorable in all cases, from the point of view of consumer surplus and total welfare.

Irrespective of quality differences, exclusive rebate contracts with the manufacturer offering the high-quality drug are to be chosen by the GPOs aiming to minimize their members' total costs. In this case the reduction of product variety is overcompensated by higher discounts.

Negotiating with the high-quality firm, the GPO minimizes costs to decide for exclusive rebate contracts instead of partially exclusive rebate contracts, irrespective of the quality differences. Under partially exclusive rebate contracts, total rebates are strictly lower than under exclusive rebate contracts. In addition, the manufacturer charges higher prices under partially exclusive rebate contracts than under exclusive rebate contracts.

For sufficiently small quality differences this holds true for rebate contracts with the low-quality firm as well. For sufficiently large quality differences, it is cost minimizing to choose the moderate form of partially exclusive rebate contracts.

Comparing partially exclusive rebate contracts with the two alternative firms, it minimizes total costs to select the low-quality firm as rebate partner.

Analyzing total welfare, we find that the ranking of the different rebate schemes clearly depends on the degree of vertical differentiation. For fairly low quality differences, partially exclusive rebate contracts are superior to exclusive rebate contracts and multiple rebate contracts lead to the highest welfare. With increasing quality differences, exclusive rebate contracts with the high-quality firm become more attractive, while multiple rebate contracts become less attractive.

The manufacturers prefer multiple rebate contracts over exclusive rebate contracts. The introduction of partially exclusive rebate contracts gives them the possibility to further increase profits.

Furthermore, we shed light on possible problems arising from the fact that GPOs often minimize expenditures instead of total costs. The GPOs are assumed to take only unit prices into consideration. Hence, they evaluate exclusive rebate contracts as equivalent, irrespective of the rebate partner. Depending on the magnitude of the quality differences, the harm to consumers changes. Besides, the GPOs tend to ignore the advantages of partially exclusive rebate contracts.

These insights of this chapter are important as they contribute to ongoing discussions in the health care sector. Contrary to some experts, we do not find arguments supporting per se the superiority of one of the rebate forms, either on the level of total costs for the members of the GPOs or on the welfare level. In fact, our model shows that quality differences play a decisive role in finding the cost-minimizing and welfare-maximizing rebate form, and these should therefore be considered carefully.

With the introduction of the Act for Restructuring the Drug Market (Arzneimittelneuordnungsgesetz, AMNOG), partially exclusive rebate contracts came into effect in Germany. Under vertical differentiation they may increase consumer surplus and total welfare, and hence they should be regarded as a third alternative. This is also in line with the practice of the Blue Cross and Blue Shield companies. They restrict their members' choice to the drugs listed on the prescription list, but members are allowed to get a prescription drug that is not listed by paying a higher copayment.

Perceived quality differences also play a part in which rebate form induces the highest consumer surplus. From the point of view of the consumers, there may be a correlation between (perceived) quality of pharmaceutical products and certain characteristics such as age, pre-existing conditions or interactions with other drugs. Analyzing the distribution of its members helps the GPOs to select the cost-minimizing rebate form.

As well as different cases that have to be distinguished mathematically, the results have to be interpreted against the background of the complex real world. There are very limited data available concerning evidence on the rebate negotiations between GPOs and manufacturers. Both parties tend to keep the details secret, thus making it difficult to model them. Therefore, we make some simplifying assumptions which are discussed below.

One simplification of our model is that in the case of exclusive rebate contracts, prices go down until the zero-profit condition is reached. However, in reality this might not be fulfilled and higher prices may be realized. Due to bargaining power, the manufacturers might be able to force the GPOs to accept even higher prices. However, it can be shown that even for higher prices, exclusive rebate contracts often yield the lowest total costs. In order to strengthen, and possibly adjust, the underlying model, it would nevertheless be useful to further investigate the bargaining process between GPOs and manufacturers.

Another aspect that is closely related to the bargaining mechanism is the rebate scheme. We simplified it to identical linear rebates based on the idea of economies of scale. In reality, though, they might well be non-linear and differing between the two manufacturers. This argument is especially relevant when comparing partially exclusive and exclusive rebate contracts. Manufacturers are supposed to grant higher rebates when GPOs can guarantee exclusivity. Nevertheless, exclusivity is often difficult to monitor, and identical rebates are offered irrespective of the contract form, which supports our assumption. Further analysis is required in order to establish which form fits real-world discount negotiations best.

Furthermore, our model also assumes that members of GPOs buy at most one unit of pharmaceutical products. In reality, hospitals, for instance, buy thousands of different products. Manufacturers may take advantage of this fact by grouping different products into bundles.

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Appendix

Proof. Multiple Rebate Contracts: For the indifferent consumer

$$V - p_1 - tx + \frac{rx^2}{x} = V - p_2 - t(1-x) + \frac{r(1-x)^2}{(1-x)} - \beta$$

has to hold, which yields the position of the indifferent consumer at $\frac{p_2 - p_1 + t + \beta - r}{2t - 2r}$. Firm i's maximization problem is given by

$$\max_{p_i} = (p_i - c)D_i(p_i, p_j) - rD_i(p_i, p_j))^2.$$

The first order condition is

$$\frac{\partial \pi_i^{MR}}{\partial p_i} = \frac{p_i(r - 2t) + c(-r + t) + t(p_j - r + t + \beta)}{2(r-t)^2} = 0.$$

This yields the solutions of $p_2^{MR} = c + t - \frac{t\beta}{3t - r}$ and $c + t + \frac{t\beta}{3t - r} = p_1^{MR}$.

Chapter 3

Rebate Contracts: A Differential-Game Approach

3.1 Introduction and Related Literature

This chapter investigates a dynamic duopoly game, building on Fershtman and Kamien (1987), Dockner (1988) and Cellini and Lambertini (2004), and introduces rebate contracts.

Worldwide, expenditures for pharmaceuticals and other medical non-durables have substantially increased over recent years. Many different attempts have been made to cut costs. Prominent among these are rebate contracts. Hospitals, nursing homes and insurance companies try to lower expenses by asking the pharmaceutical manufacturers to grant rebates.

Analyzing rebate contracts, two approaches have to be distinguished. On the one hand, rebates may result from laws and acts. The worldwide focus on savings has led to the introduction of compulsory discounts as one of several approaches. One example of a legally fixed discounts is rebates of up to 16 percent on the list prices. Manufacturers in Germany are legally obliged to grant these (Bundesministerium für Gesundheit (2012)). In 2010, these legally fixed rebate contracts led, according to Coca and Nink (2011), to savings of about 1.5 billion euros. Alternatively, manufacturers can themselves decide to offer rebates, possibly also additional to the compulsory ones. Very often hospitals, nursing homes and other health care providing organizations bundle their demand, to exercise buyer power. As a consequence, they determine the amount of rebates the manufacturers have to grant. Buyer power and the resulting rebates may depend on individual characteristics of the buyers, such as brand loyalty, or on special contract conditions or advertising campaigns. In Germany, individually negotiated rebate contracts between pharmaceutical manufacturers and insurance companies led, according to Korzilius (2011), to total savings of about 1.1 billion euros in 2010.

Consequently, both mandatory and compulsory rebate contracts have an effect on prices and quantities in equilibrium. The aim of this chapter is to set up a theoretical model to analyze the impact of rebate contracts.

There exist various papers on rebate contracts in very different contexts. Kolay et al. (2004) find that rebates may eliminate double marginalization and may improve welfare. Greenlee and Reitman (2006) state that where of consumers hold strong preferences for certain products, rebate contracts may lead to an increase in producer surplus. Greenlee et al. (2007) show that rebate contracts are one possible tool to leverage market power from one monopolized market into another. Elhauge (2008) proves that rebate contracts may create anticompetitive effects, as they decrease the incentive to compete for free buyers by lowering prices. Based on this heterogeneous literature and the OECD Roundtable on "Fidelity and Bundled Rebates and Discounts" (2008), the overall impact of rebate contracts on prices and quantities in equilibrium is unclear.

On top of that, major assumptions of these articles are either static prices over time or that there is an instantaneous and permanent price adjustment. However, neither of these concepts fits in reality in the health care context. Prices and quantities are adjusted, but not instantaneously. The demand adjustment in the health care context reacts rather sluggishly. This may either be due to menu costs or fixed contract durations. It implies that it takes some time before price changes are observed and acted upon in the market. Consequently, within certain intervals prices and quantities are not derived from the demand curve, but are assumed to be fixed. The length of these intervals varies, depending on, for example, the size of the affiliates. Hence, manufacturers know that prices will decrease if their joint output exceeds the level of demand at that price, but not instantaneously, and firms try to exploit this lagged price adjustment.

One example for these sluggish adjustments is rebate contracts between pharmaceutical manufacturers and hospitals. Typically such contracts, including detailed agreements on prices, quantities and rebates, are conducted at the beginning of the year and run for one year. At the end of each year, an adjustment takes place, based on the precious year's consumption.

The chapter is, to the best of our knowledge, the first that provides a theoretical model dealing with rebate contracts in a dynamic context.

The dynamic demand concept of sticky prices has also been used by Brekke et al. (2010) and Siciliani et al. (2013), but in the context of quality in the health care sector. And by Piga (1998a, 1998b), who model advertising, which, affects the demand curve similarly to rebates.

We use this demand concept in a market for a homogeneous good with dynamic duopolistic competition, introducing rebate contracts. This comprises three distinct behavior rules, followed by the manufacturers, depending on the information set available: the open-loop, the feedback and the closed-loop solution concepts.

In the case of the open-loop solution concept, the manufacturers can observe the initial state of the world, but not the dynamics of the system, that is the actions taken by the other players. Hence, they have to determine their optimal dynamic plans at the beginning of the game, without the ability to correct them afterwards. This commitment implies that open-loop equilibria are mostly not subgame perfect. The additional shortfall of this solution concept is that there is no true strategic interaction between the players over time. However, it is appropriate in games in which the players only have information on their own actions and timing or follow short-term operational or tactical planning. Depending on the experience of the firms and the specific products sold, these requirements hold in the health care sector. Consequently, the open-loop equilibrium concept is used as a benchmark case.

Alternatively, firms may take into account strategic interactions through the evolution of state variables and the associated adjustment of the control variables. Thus, they solve the game either based on feedback or closed-loop solution concepts. If the manufacturers can base their decisions on the accumulated stock of each state variable at any point in time, feedback solution concepts are employed.

The closed-loop equilibrium on the other hand, accounts for the initial and current state of the world of each decision variable. For an exhaustive theoretical discussion of these solution concepts see Mehlmann (1988), Basar and Olsder (1995) and Dockner et al. (2000).

We find that for all three dynamic solution concepts, quantities and prices in equilibrium increase with increasing prohibitive price. Quantities decrease with increasing costs, while prices increase.

Prices and quantities in equilibrium under the dynamic solution concepts differ from the static ones. Under Cournot competition and perfect competition, prices net of rebates and quantities in equilibrium are unaffected by rebate contracts. In the optimum, the manufacturers increase their prices by the amount of rebates they grant. Consequently, considering static solution concepts, rebate contracts are not an appropriate instrument to sustainably influence equilibrium outcomes.

Under the three dynamic solution concepts prices and quantities in equilibrium differ due to two aspects. Introducing dynamic price adjustment leads to increasing (decreasing) quantities (prices) in equilibrium compared to static Cournot competition. Additionally, and in contrast to static solution concepts, rebates are not entirely captured by higher prices, but affect equilibrium outcomes. Increasing rebates stimulate demand, leading to higher prices. However, the demand-stimulating effect lags behind. Thus, the price increase is too small to internalize the total effect, which induces decreasing prices net of rebates granted. Consequently, quantities (prices) derived from dynamic solution concepts are, in the limit, lower (higher) than under static perfect competition.

Comparing equilibrium prices under the dynamic solution concepts, prices under the closed-loop solution are lower than those under the feedback solution. Prices under the open-loop solution concept exceed both the others. Equilibrium quantities, on the contrary, are lowest derived from the open-loop concept followed by those in the feedback case and closed-loop solution concepts. The ranking is due to the different sizes of firms' information sets. An increase in the information set leads to overproduction compared to the outcome under the open-loop solution concept. Consequently, manufacturers prefer the open-loop equilibrium to the feedback, and feedback to the closed-loop equilibrium. When consumer surplus is the maximand, the opposite ordering holds true.

For myopic firms, or if the actual price does not adjust at all to the price given by the demand function, prices and quantities under the three dynamic solution concepts converge to the equilibrium under perfect competition.

In the case of farsighted manufacturers or instantaneous price adjustment, the equilibrium under the open-loop solution coincides with that under Cournot competition. Applying feedback or closed-loop solution concepts, quantities (prices) are above (below) the Cournot quantity (price).

Analyzing equilibrium outcomes of the dynamic solution concepts, we find that the evolution of equilibrium quantities and prices depends on rebates. The differences between quantities and prices under the dynamic solution concepts vanish with increasing rebates granted. Additionally, with rising discounts, quantities and prices net of rebates in equilibrium approach quantities and prices under perfect competition.

Based on the combination of rebate contracts and dynamic solution concepts, this chapter also provides a theoretical model for the evidence-based discussion on the harms and benefits of rebate contracts. Compulsory discounts are widely used in various countries to reduce expenditures in the health care sector. However, as we show in this chapter, predicting and adjusting the effects of rebate contracts on prices and quantities in equilibrium by static solution concepts may be misleading. Thus, by evaluating the impact of dynamic solution concepts, we provide alternative instruments, and contribute to the growing body of literature on health care issues.

The rest of the chapter is organized as follows: Chapter 3.2 introduces the underlying duopolistic model with sticky prices. Chapter 3.3 derives the equilibrium outcome under the benchmark open-loop case. The feedback solution concept is presented in chapter 3.4, and the closed-loop solution concept in chapter 3.5. All three solution concepts are compared in chapter 3.6. Chapter 3.7 concludes the chapter.

3.2 Setup

Our model is based on the concept of duopolistic competition. We assume that, at any point in time $t \in [0, \infty]$, two manufacturers produce a homogeneous good.

The output of each duopolist is denoted by $x_i(t)$, with $i = 1, 2$ and the identical discounts they offer by $rp(t)$, with $r \in [0, 1]$. Total costs are given by quadratic production costs $C_i(x_i(t)) = cx_i(t)^2, c > 0$, augmented by the total costs caused by rebates granted $R(x_i(t)) = rp(t)x_i(t)$, depending on the quantity sold by each of the firms. In each period, market demand determines the price. It is linear and downward sloping and for identical discounts given by

$$\hat{p}(t) = a - b[x_i(t) + x_j(t)] + rp(t). \tag{3.1}$$

The dynamic moment in this model is derived from the stickiness assumption, as far as prices are concerned. This implies that the market price $p(t)$ does not adjust instantaneously to the price indicated by the demand function $\hat{p}(t)$. Prices may vary, because of menu costs or fixed contract durations, from those derived from the demand function. In the health care context, prices are usually negotiated for certain periods and do not adapt instantaneously, leading to a sluggish adjustment. Consequently, $\hat{p}(t)$ based on the demand curve will in general differ from the market price $p(t)$, set by the manufacturers. Prices adjust according to

$$\frac{dp(t)}{dt} \equiv \dot{p}(t) = \gamma[\hat{p}(t) - p(t)]. \tag{3.2}$$

Prices react proportionally to the difference between the price determined by the inverse demand function and the market price. The speed of the adjustment is defined by the constant γ, with $0 < \gamma < \infty$. In the health care sector, past consumption of drugs has consequences on current consumption decisions. As Fershtman and Kamien (1987) show, this is also reflected by γ. For a smaller γ the effect of past consumption on today's marginal utility is larger, and thus current prices are also larger. Based on a quadratic cost function and quantity discounts, manufacturer i's profit function is given by

$$\pi_i = [p(t) - rp(t)]x_i(t) - cx_i(t)^2.$$

Hence, the maximization problem of firm i amounts to

$$\max_{x_i(t)} \int_0^\infty e^{-\rho t}[p(t) - rp(t)]x_i(t) - cx_i(t)^2 dt,$$

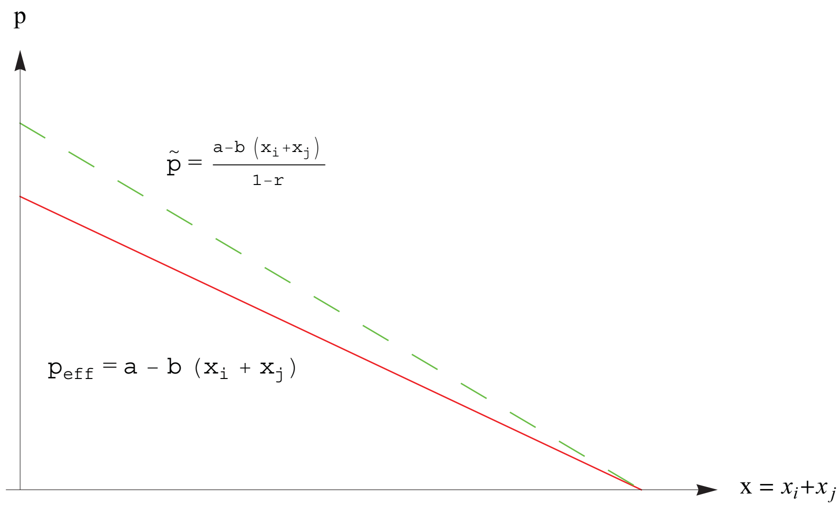
with $\rho \geq 0$ being the intertemporal discount rate and subject to equation (3.1) and conditions $p(0) = p_0$ and $p(t) \geq 0$ for all $t \in [0, \infty]$.

For illustrative purposes, we first present the equilibrium outcomes under the static solution concepts. Assuming these solution concepts, the demand function adjusts instantaneously and is specified by

$$p = a - b(x_i + x_j) + rp \leftrightarrow p = \frac{a - b(x_i + x_j)}{1 - r}.$$

The effect of rebate contracts on the demand curve is illustrated in Figure 3.1.

Figure 3.1: Effect of rebate contracts on the demand curve



Based on the firms' profit function, quantities (x_i^{Cour}), prices (p^{Cour}), and prices net of rebates (p_{eff}^{Cour}), in equilibrium under static Cournot competition amount to

$$x_i^{Cour} = \frac{a}{3b + 2c}, \quad p^{Cour} = \frac{a(b + 2c)}{(3b + 2c)(1 - r)} \quad \text{and} \quad p_{eff}^{Cour} = \frac{a(b + 2c)}{3b + 2c}.$$

The effective price is defined as the price net of rebates.

On the other hand, the static "competitive" quantities and prices, with firms behaving according to the rule "marginal costs equal price", are given by

$$x_i^{PC} = \frac{a}{2(b+c)}, \quad p^{PC} = \frac{ac}{(b+c)(1-r)} \quad \text{and} \quad p_{eff}^{PC} = \frac{ac}{b+c}.$$

In line with Fershtman and Kamien (1987), both concepts are taken as a reference point.

Using static solution concepts, neither quantities in equilibrium nor effective prices are affected by rebates granted. Firms adjust their prices in equilibrium to compensate themselves for the rebates they have to grant. Thus, no savings for the consumers can be realized. This is in contrast to the effects observed after the introduction of rebate contracts.

To gain an understanding of the effect of sluggish price adjustment and rebate contracts, we introduce a two-period game. Assuming that the two firms maximize their profits for two periods, prices adjust with a lag of one period. Abstracting from the intertemporal discount rate ρ, for each firm the profit function is given by

$$\pi_i = [p(1) - rp(1)]x_i(1) - cx_i(1)^2 + [p(2) - rp(2)]x_i(2) - cx_i(2)^2.$$

Due to the sluggish price adjustment, $p(2)$ is assumed to be constant, independent from quantities set in the second period, and $p(2) = p(1)$ holds. Applying Cournot competition and using backward induction, quantities, prices, and prices net of rebates in equilibrium are given by

$$x_i(1) = \frac{a(b-2c)}{2b^2 - 2c(3b+2c)}, \quad x_i(2) = \frac{-a(b+2c)}{2b^2 - 2c(3b+2c)},$$

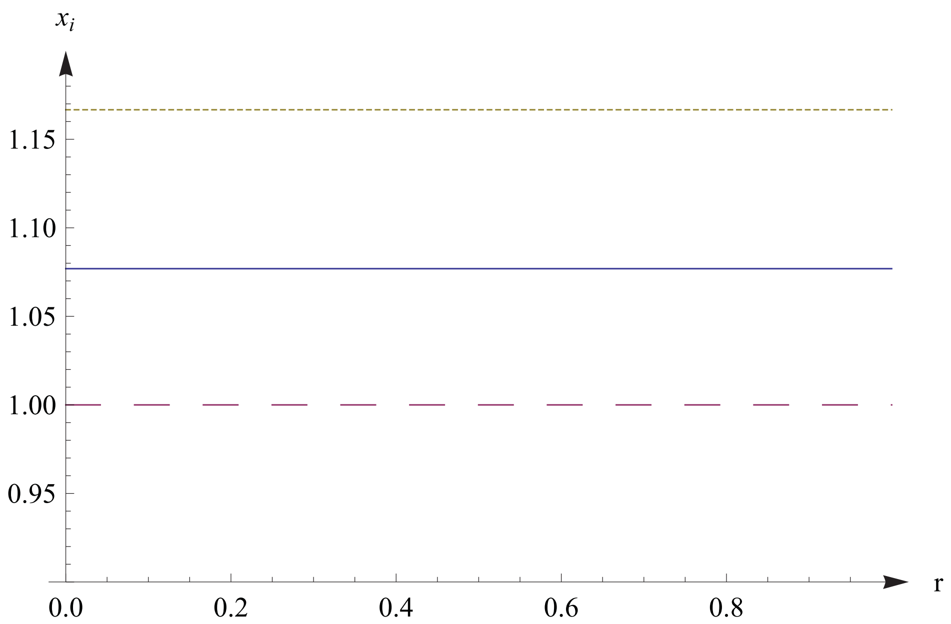
$$p(1) = p(2) = \frac{ac(b+2c)}{(1-r)\left[c(3b+2c) - b^2\right]}, \quad p(1)^{eff} = p(2)^{eff} = \frac{ac(b+2c)}{c(3b+2c) - b^2}.$$

Compared to the static case, firms try to exploit the sluggish price adjustments in the two-stage game.[1] As prices react with a lag of one period, firms expand their production in the second period, selling at constant prices. Comparing quantities

[1]To insure positive quantities in equilibrium, $b < 2c$ has to hold.

in equilibrium, we find that $x_i(1) < x_i^{Cour}(t) < x_i^{PC}(t) < x_i(2)$ applies. However, the average quantity in the two-stage game $\bar{x}_i$ is higher than in the Cournot game but lower than in the corresponding competitive game, which is illustrated in Figure 3.2. These findings shed light on the fact that in dynamic games with sluggish

Figure 3.2: Equilibrium quantities under static and two periods games



x_i^{Cour} (dashed line) vs. $\bar{x}_i$ (solid line) vs. x_i^{PC} (pointed line), $(a = 7, b = 1, c = 2)$.

demand, average quantities in equilibrium are higher than under static Coutnot competition, but lower than the under static perfect competition.

So far rebate contracts have no effect on quantities and prices net of rebates in equilibrium. However, in the dynamic cases the equilibrium solutions also depend on rebates granted. We present three different solution concepts in this context, subject to the information set available: the open-loop, the feedback and the closed-loop solution concept. In doing so, we show that rebate contracts further increase quantities and decrease prices net of rebates in equilibrium.

3.3 Open-loop Solution

Under the open-loop solution concept, both firms can observe the initial state of the world, but not the dynamics of the system. Therefore, they have to commit to their optimal plans at $t = 0$, without the possibility of changing them during the game. Let λ_i be the current co-state variable. Then the current-value Hamiltonian of firm i is given by

$$\mathcal{H}_i(t) = [p(t) - rp(t)]x_i(t) - cx_i(t)^2 + \lambda_i(t)\gamma[a - b(x_i(t) + x_j(t)) + rp(t) - p(t)] \quad (3.3)$$

where $\lambda_i(t) = \mu_i(t)e^{-\rho t}$ holds and $\mu_i(t)$ is the co-state variable, associated with $p(t)$. Based on the Hamiltonian function, the open-loop solution can be summarized as follows:

Proposition 5. *The open-loop Nash equilibrium yields the steady state individual outputs and prices of*

$$x_i^{OL} = \frac{a(1-r)\gamma + a\rho}{(3b+2c)(1-r)\gamma + 2(b+c)\rho}$$

and

$$p^{OL} = \frac{a(b+2c)(1-r)\gamma + 2ac\rho}{(1-r)[(3b+2c)(1-r)\gamma + 2(b+c)\rho]}.$$

The pair $\{x_i^{OL}, p^{OL}\}$ constitutes a saddle point.

Proof. The solution is derived from the first-order condition, w.r.t. $x_i(t)$, using equation (3.3) and the adjoint conditions for the optimum and given by

$$\frac{\partial \mathcal{H}_i(t)}{\partial x_i(t)} = p(t) - rp(t) - 2cx_i(t) - \lambda_i(t)\gamma b = 0, \quad (3.4)$$

$$\dot{\lambda}(t) = \lambda_i(t)\rho - x_i(t) + rx_i(t) - \gamma\lambda_i(t)r + \gamma\lambda_i(t),$$

$$\dot{p}(t) = \frac{\partial H_i(t)}{\partial \lambda_i(t)} = \gamma[\hat{p}(t) - p(t)].$$

In line with Fershtman and Kamien (1987), equation (3.4) is a variation of marginal costs equal marginal revenues, with marginal revenues consisting of the effective price and the long-run effect of a marginal change in the output rate of $-\lambda_i(t)\gamma b$.

Differentiating equation (3.4) with respect to time yields

$$\dot{x}_i(t) = \frac{\dot{p}(t) - r\dot{p}(t) - \dot{\lambda}_i(t)\gamma b}{2c}.$$

Using equation (3.1), (3.2) and (3.4), and a symmetry assumption, this simplifies to

$$\dot{x}_i(t) = \frac{(1-r)[a - 2p(1-r) + 2cx_i(t) - bx_j(t)]\gamma + [2cx_i(t) - p(1-r)]\rho}{2c}.$$

At a steady state no changes in the system can be observed over time, yielding $\frac{dp(t)}{dt} = \frac{dx_i(t)}{dt} = 0$. The dynamic system can be rewritten in the matrix form of

$$\begin{bmatrix} \dot{p} \\ \dot{x}_i \\ \dot{x}_j \end{bmatrix} = \begin{bmatrix} \gamma(r-1) & -\gamma b & -\gamma b \\ \frac{-2\gamma(1-r)^2 - \rho(1-r)}{2c} & \frac{2c\gamma(1-r)+2c\rho}{2c} & \frac{-b\gamma(1-r)}{2c} \\ \frac{-2\gamma(1-r)^2 - \rho(1-r)}{2c} & \frac{-b\gamma(1-r)}{2c} & \frac{2c\gamma(1-r)+2c\rho}{2c} \end{bmatrix} \begin{bmatrix} p \\ x_i \\ x_j \end{bmatrix} + \begin{bmatrix} \gamma a \\ \frac{(1-r)a\gamma}{2c} \\ \frac{(1-r)a\gamma}{2c} \end{bmatrix}.$$

Since the determinate of the above (3x3) matrix is negative, the given equilibrium point is saddle, yielding

$$x_i^{OL} = \frac{a(1-r)\gamma + a\rho}{(3b+2c)(1-r)\gamma + 2(b+c)\rho}$$

and

$$p^{OL} = \frac{a(b+2c)(1-r)\gamma + 2ac\rho}{(1-r)[(3b+2c)(1-r)\gamma + 2(b+c)\rho]}.$$

This concludes the proof. □

The prices net of rebates in equilibrium are given by $p_{eff}^{OL} = \frac{a(b+2c)(1-r)\gamma+2ac\rho}{(3b+2c)(1-r)\gamma+2(b+c)\rho}$. In line with standard results and Fershtman and Kamien (1987), quantities and prices rise with increasing prohibitive price a. Quantities (prices) decrease (increase) with increasing marginal costs c and adjustment speed parameter γ, while quantities (prices) increase (decrease) with rising discount factor ρ. For r converging to zero, quantities and prices coincide with those highlighted by Fershtman and Kamien (1987).

Prices are equivalent to the static Cournot price $p^{Cour} = \frac{a(b+2c)}{(3b+2c)(1-r)}$, if the discount rate ρ goes zero or, using l'Hospital's rule, if the adjustment speed parameter

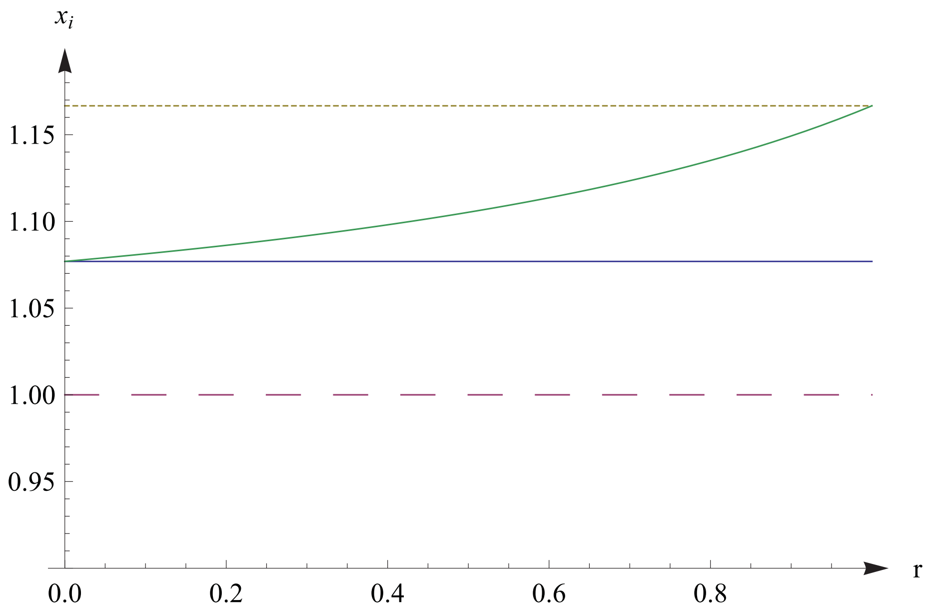
γ tends to infinity.

On the other hand, infinitely high discount rates induce lower importance of future consumption. Hence, the duopolists no longer focus on the results of today's actions on future outcomes, and in our model set marginal costs equal to marginal revenues, that is effective prices. This results in perfectly competitive prices. The same holds true for γ converging to zero.

Contrary to the static solution concepts, equilibrium outcomes under the open-loop solution concept also depend on rebates granted. Increasing rebates lead to higher quantities and prices in equilibrium. However, the effective prices net of rebates decrease with increasing rebates granted. Due to the stickiness of the demand function, the price reaction is positive, but too small to compensate firms for the increasing rebates they have to pay. This leads to decreasing prices net of rebate.

The differences between static, two-period games, and the open-loop solution concept are depicted in Figure 3.3. Setting $\rho = 1$ and $\gamma = 1$, prices react with a lag of one period. Consequently, the open-loop solution and the two-period game coincide where no rebates are granted. However for $r > 0$, quantities in equilibrium are higher under the open-loop solution concept than under the two periods game, due to the positive effect of rebates on quantities. In the limit of r approaching 1, quantities in equilibrium converge to quantities under perfect competition. These effects of rebates on equilibrium outcomes can also be found for the other two dynamic solution concepts.

Figure 3.3: Equilibrium quantities under static and open-loop games



x_i^{Cour} (dashed line) vs. $\bar{x}_i$ (solid line) vs. x_i^{OL} (solid curve) vs. x_i^{PC} (pointed line), $(a = 7, b = 1, c = 2, \rho = 1, \gamma = 1)$.

3.4 Feedback Solution

The open-loop solution concept is appropriate if the manufacturers compute the quantities they offer in $t = 0$, and stick to them throughout the whole game. Contrarily, as is also observed in the health care context, firms may react upon the evolution of the game, by changing the qualities they offer. In these cases, the game is solved using feedback or closed-loop solution concepts. The feedback solution concept is appropriate for firms accounting for the accumulated stock of each decision variable at any point in time. Using Bellman's value function approach, the feedback solution can be derived and must satisfy the Hamilton-Bellman-Jacobi equation

$$\rho V_i(p(t)) = \max_{x_i(t)} \{[p(t) - rp(t)]x_i(t) - cx_i(t)^2 + \frac{\partial V_i(p(t))}{\partial p(t)} \gamma [\hat{p}(t) - p(t)]\}, \qquad (3.5)$$

where $V_i(p(t))$ is the value function for firm $i = 1, 2$. Based on the linear quadratic form of the maximand, and in line with Fershtman and Kamien (1987), we use the quadratic value function

$$V_i(p(t)) = \frac{k_i p(t)^2}{2} + h_i p(t) + l_i.$$

Proposition 6. *The feedback Nash equilibrium yields the steady state individual outputs and prices of*

$$x_i^{FB} = \frac{bh^*(1-r)\gamma + a(r-1+bk^*\gamma)}{2(b+c)(r-1)+2b^2k^*\gamma},$$

and

$$p^{FB} = \frac{ac + b^2h^*\gamma}{(b+c)(1-r) - b^2k^*\gamma},$$

where

$$k^* = \frac{2(b+c)(1-r)\gamma + c\rho - \psi}{3b^2\gamma^2}$$

and

$$h^* = \frac{2ac\left[2(b+c)(1-r)\gamma + c\rho - \psi\right]}{3b^2\gamma\,(c\rho+\psi)},$$

with

$$\psi := \sqrt{(b^2+8bc+4c^2)\,(-1+r)^2\gamma^2 - 4c(b+c)(-1+r)\gamma\rho + c^2\rho^2}.$$

The pair $\{x_i^{FB}, p^{FB}\}$ constitutes a saddle point.

Proof. Differentiating equation (3.5) with respect to $x_i(t)$, we obtain:

$$x_i(t) = \frac{p(t) - rp(t) - bh_i\gamma - bk_ip(t)\gamma}{2c},$$

which simplifies, using symmetry conditions, to

$$x(t) = \frac{p(t) - rp(t) - bh\gamma - bkp(t)\gamma}{2c}. \tag{3.6}$$

Based on equation (3.2) and (3.6), we find that

$$p^{FB} = \frac{ac + b^2h\gamma}{(b+c)(1-r) - b^2k\gamma}.$$

Rewriting equation (3.5), the optimal values for h and k can be derived by

$$\rho V_i(p(t)) - \max_{x_i(t)}\{[p(t) - rp(t)]x_i(t) - cx_i(t)^2 + \frac{\partial V_i(p(t))}{\partial p(t)}\gamma[\hat{p}(t) - p(t)]\} = 0$$

or

$$\alpha p^2 + \beta p + \xi = 0, \tag{3.7}$$

with

$$\alpha = \frac{-1 + 2r - r^2 - 4(b+c)kr\gamma - k\gamma\left(-4(b+c) + 3b^2k\gamma\right) + 2ck\rho}{4c},$$
$$\beta = \frac{-\gamma\left[2c(ak + h(-1+r)) + 2bh(-1+r) + 3b^2hk\gamma\right] + 2ch\rho}{2c},$$
$$\xi = -\frac{h\gamma\left(4ac + 3b^2h\gamma\right)}{4c} + l\rho.$$

Equation (3.7) is fulfilled, if the coefficients α, β and ξ are simultaneously zero. This yields the following solution for the three variables $\{k, h, l\}$:

$$k_{1,2} = \frac{2(b+c)(1-r)\gamma + c\rho \pm \psi}{3b^2\gamma^2},$$
$$h = \frac{2ack^*\gamma}{\gamma\left(2(b+c)(1-r) - 3b^2k^*\gamma\right) + 2c\rho} \equiv h^*,$$
$$l = \frac{h^*\gamma\left(4ac + 3b^2h^*\gamma\right)}{4c\rho}.$$

To guarantee stability, we must choose the smaller solution of $k_{1,2}$ for k^*.
This concludes the proof. □
The price net of rebates is given by $p_{eff}^{FB} = \frac{(1-r)\left(ac+b^2h^*\gamma\right)}{(b+c)(1-r)-b^2k^*\gamma}$. As far as the effects of the prohibitive price a, marginal costs c, the adjustment parameter γ and the discount factor ρ are concerned, the same dynamics hold true as in the case of the open-loop solution concept.

For infinitely large discount rate or zero adjustment of the price, the feedback equilibrium prices converge to the equilibrium under perfect competition. In the case of ρ going to zero, prices are below the corresponding ones under Cournot competition.

As well as for the open-loop solution concept, increasing rebates lead to rising quantities and decreasing effective prices in equilibrium. In the limit, equilibrium outcomes converge to the corresponding ones under perfect competition, and consequently coincide with the outcomes for the open-loop solution concept.

3.5 Closed-loop Solution

According to the closed-loop solution rule, interactions between the quantities the opponent sets and the state variable $p(t)$ have to be considered at any point in time. This gives rise to the steady state quantities and prices summarized in Proposition 7.

Proposition 7. *The closed-loop Nash equilibrium yields the steady state prices and individual outputs of*

$$x_i^{CL} = \frac{a(b+2c)(1-r)\gamma + 2ac\rho}{2\left(b^2+4bc+2c^2\right)(1-r)\gamma + 4c(b+c)\rho}$$

and

$$p^{CL} = \frac{2ac[(b+c)(1-r)\gamma + c\rho]}{(1-r)\left[\left(b^2+4bc+2c^2\right)(1-r)\gamma + 2c(b+c)\rho\right]}.$$

The pair $\{x_i^{CL}, p^{CL}\}$ constitutes a saddle point.

Proof. The first-order condition w.r.t. x_i, coincides with equation (3.4), calculated in the open-loop case. The adjoint condition for the optimum is given by

$$\begin{aligned}\dot{\lambda}_i(t) &= \rho\lambda_i(t) - \frac{\partial\mathcal{H}_i(t)}{\partial p(t)} - \frac{\partial\mathcal{H}_i(t)}{\partial x_j(t)}\frac{\partial x_j^{CL}}{\partial p(t)} \\ &= \rho\lambda_i(t) - x_i(t) + r x_i(t) - r\lambda_i(t)\gamma + \lambda_i(t)\gamma + \frac{b(1-r)\gamma\lambda_i(t)}{2c}.\end{aligned}$$

The last term of the co-state equation characterizes the strategic interaction between the two firms. Differentiating equation (3.4) with respect to time and using the co-state equation, leads to

$$\dot{x}_i(t) = \frac{(1-r)\gamma[2c(a-p(t)+rp(t)-bx_j(t)) - b(b+2c)\gamma\lambda_i(t)] - 2bc\gamma\lambda_i(t)\rho}{4c^2}.$$

As in the open-loop case, $\frac{dp(t)}{dt} = \frac{dx_i(t)}{dt} = 0$ has to hold and this yields

$$x_i^{CL} = \frac{a(b+2c)(1-r)\gamma + 2ac\rho}{2\left(b^2+4bc+2c^2\right)(1-r)\gamma + 4c(b+c)\rho}$$

and

$$p^{CL} = \frac{2ac[(b+c)(1-r)\gamma + c\rho]}{(1-r)\left[\left(b^2+4bc+2c^2\right)(1-r)\gamma + 2c(b+c)\rho\right]}$$

as the unique steady state of the system. The dynamic system can be written in matrix form to verify that the pair $\{x_i^{CL}, p^{CL}\}$ constitutes a saddle point.
This concludes the proof. □

The price net of rebates is given by $p_{eff}^{CL} = \frac{2ac[(b+c)(1-r)\gamma+c\rho]}{\left(b^2+4bc+2c^2\right)(1-r)\gamma+2c(b+c)\rho}$. As far as the effects of the prohibitive price a, marginal costs c, the adjustment parameter γ and the discount factor ρ are concerned, the same dynamics hold true as in the case of the open-loop solution concept. For ρ going to infinity or γ converging to zero, prices in the closed-loop equilibrium converge to the perfect competitive prices. In the case of zero discount rate or instantaneous adjustment of prices, the closed-loop equilibrium price converges to a price below the static Cournot prices.

For the closed-loop solution, as well as for the other dynamic solution concepts, rising rebates yield increasing quantities and decreasing effective prices in equilibrium. As presented in the previous chapters, in the limit equilibrium outcomes converge to quantities and prices set under perfect competition.

3.6 Comparative Assessment of the Steady States

Analyzing the equilibrium prices and quantities for the different dynamic solution concepts above, as well as for the static cases, we find

Proposition 8. *For all $\gamma \in [0, \infty[$, we have*

$$p_{eff}^{PC} \leq p_{eff}^{CL} \leq p_{eff}^{FB} \leq p_{eff}^{OL} \leq p_{eff}^{Cour} \quad \textit{and} \quad x_i^{Cour} \leq x_i^{OL} \leq x_i^{FB} \leq x_i^{CL} \leq x_i^{PC}.$$

Comparing dynamic equilibrium prices and quantities to those under the static solution concepts, we find that quantities are exaggerated (understated) while prices are understated (exaggerated), compared to Cournot competition (perfect competition).

The differences in the open-loop, feedback and closed-loop equilibrium prices are due to the increase in the information set. Under the open-loop solution, it is not possible for firms to strategically interact, while under the feedback solution they may account for the accumulated stock of each decision variable. Most information is available under the closed-loop solution, with firms acting upon the initial and the current state of the world.

Larger information sets lead to overproduction, compared to the open-loop equilibrium. Among the subgame perfect solution concepts, the feedback equilibrium minimizes overproduction. These findings regarding the relative positions of the three solution concepts are in line with Fershtman and Kamien (1987).

As far as prices net of rebates are concerned, the same ordering applies as for equilibrium prices. Consequently, both firms prefer the open-loop equilibrium to the feedback equilibrium and the latter to the closed-loop equilibrium.

Analyzing the open-loop, feedback and closed-loop solution concept, we find that for all three dynamic solution concepts quantities and prices in equilibrium increase with increasing prohibitive price a. Quantities decrease with increasing costs c, while prices increase.

For ρ going to infinity or γ converging to zero, prices and quantities under the three dynamic solution concepts converge to the perfect competitive prices and quantities. For ρ going to zero or γ approaching infinity, prices and quantities under the closed-loop solution concept converge to the equilibrium under Cournot competition. However, under the feedback or open-loop solution concept, prices are below the static Cournot prices and quantities above the corresponding ones. Under the two subgame perfect solution concepts, firms base their output decisions on the current price and the dynamic interactions of the game. This results in higher output rates than under the static Cournot competition.

Contrary to the static solution concepts, equilibrium outcomes under the dynamic solution concepts also depend on rebates granted. Rising rebates lead to increasing quantities and prices in equilibrium, with $\frac{\partial^2 x_i}{\partial^2 r} > 0$ and $\frac{\partial^2 p}{\partial^2 r} > 0$, for the three dynamic solution concepts. Though, the effective prices net of rebates, decrease with increasing rebates granted with $\frac{\partial^2 p_{eff}}{\partial^2 r} < 0$.

Due to the stickiness of the demand function, the price reaction is positive but too small to compensate firms for the increasing costs due to higher rebates. Consequently, prices net of rebate decrease, which generates a negative effect on firms' profits, irrespective of the dynamic solution concept.

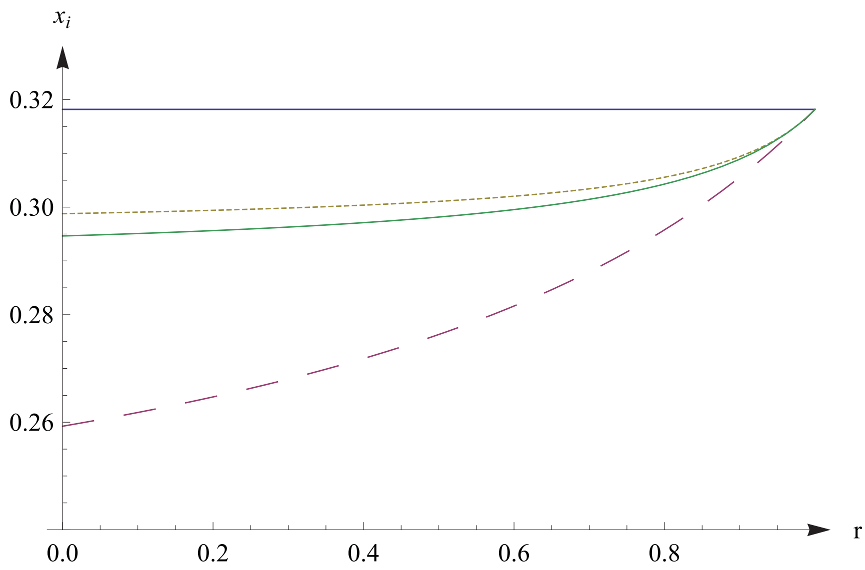
The effect of rebates on quantities in equilibrium decreases with increasing information sets available, that is from open-loop to feedback to closed-loop solutions. The impact on effective prices in equilibrium depends on rebates granted. For sufficiently low rebates $\frac{\partial p^{CL}}{\partial r} < \frac{\partial p^{FB}}{\partial r} < \frac{\partial p^{OL}}{\partial r}$ applies. With increasing rebates, the ordering changes from $\frac{\partial p^{CL}}{\partial r} < \frac{\partial p^{OL}}{\partial r} < \frac{\partial p^{FB}}{\partial r}$ to $\frac{\partial p^{OL}}{\partial r} < \frac{\partial p^{CL}}{\partial r} < \frac{\partial p^{FB}}{\partial r}$. For r exceeding a threshold depending on a, b, c, ρ and γ, $\frac{\partial p^{OL}}{\partial r} < \frac{\partial p^{FB}}{\partial r} < \frac{\partial p^{CL}}{\partial r}$ holds true. The same applies for effective prices.

In the limit of r converging to 1, prices net of rebates under the three dynamic solution concepts coincide and converge to prices under perfect competition. Consequently, rebates have in the limit the same effect as infinitely high discount rates or no price adjustment at all.

The introduction of rebate contracts leads to higher quantities and lower prices in equilibrium, irrespective of the solution concept. On the other hand, for a given rebate, larger information sets yield higher quantities and lower prices. Thus, rebate contracts may act as compensation for lacking information. In combination with the fact that the implementation of rebate contracts is much easier than increasing the information set, rebate contracts are an important policy device.

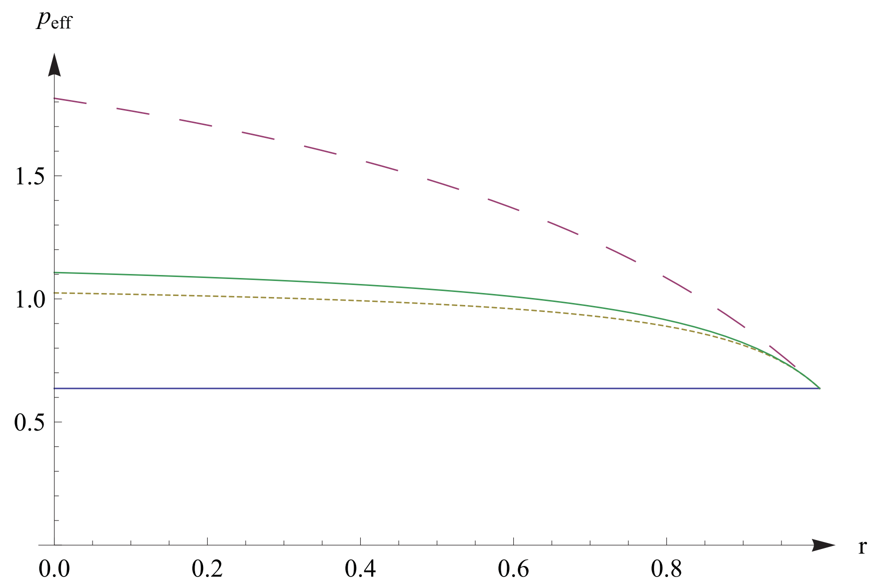
Figure 3.4 and 3.5 illustrate the relationship between equilibrium quantities and prices net of rebates and rebates granted. We also included the corresponding solutions under perfect static competition. For illustrative purposes $a = 7$, $b = 10, c = 1, \rho = 2, \gamma = 2$ for all solution concepts.

Figure 3.4: Equilibrium quantities x_i depending on the solution concepts



x_i^{OL} (dashed curve) vs. x_i^{FB} (solid curve) vs. x_i^{CL} (pointed curve) vs. x_i^{PC} (solid line) as a function of rebates r, $(a = 7, b = 10, c = 1, \rho = 2, \gamma = 2)$.

Figure 3.5: Equilibrium prices net of rebates p_{eff} depending on the solution concepts



p_{eff}^{PC} (solid line) vs. p_{eff}^{CL} (pointed curve) vs. p_{eff}^{FB} (solid curve) vs. p_{eff}^{OL} (dashed curve) as a function of rebates r, $(a = 7, b = 10, c = 1, \rho = 2, \gamma = 2)$.

3.7 Conclusion

This chapter develops a model of differential games, based on Fershtman and Kamien (1987), Dockner (1988) and Cellini and Lambertini (2004), whereby firms grant discounts. Unlike existing literature on rebate contracts, we assume that prices cannot adjust instantaneously and instead they react sluggishly. We provide three different solution concepts: the open-loop, the feedback and the closed-loop solution. Under the first one of these, firms have to commit to an optimal strategy at the beginning of the game and stick to it. Under the other two solution concepts, there exist strategic interactions between the opponents, who can base their decisions on time and the current state of the variables. Under the feedback solution, firms may account for the accumulated stock of each decision variable. The most information is available under the closed-loop solution, with the manufacturers considering the initial and the current state of the world.

Prices and quantities in equilibrium under the open-loop, the feedback and the closed-loop solution concepts differ from the static ones. Under Cournot competition, prices exceed prices derived from the dynamic solution concepts, while quantities are lower than the corresponding quantities. In contrast, under perfect competition, prices are understated and quantities exaggerated compared to the dynamic solution concepts.

However, if either of the firms are myopic or the actual price is not at all influenced by the demand function, prices in equilibrium under the open-loop, feedback and closed-loop solution concepts coincide with the prices under perfect competition. In the case of farsighted producers or instantaneous price adjustments, equilibrium prices derived from the open-loop solution equal prices under Cournot competition, whereas prices under the feedback and closed-loop solutions are below those prices.

The foregoing analysis also shows that the subgame perfect closed-loop and feedback solution concepts yield weakly higher outputs than the weakly time-consistent open-loop solution concepts. Among the subgame perfect equilibria, the closed-loop one induces higher outputs than the feedback equilibrium. As far as prices in equilibrium are concerned, the opposite holds true. Largest prices evolve under open-loop solution concepts, followed by feedback and closed-loop solutions. Thus, for larger information sets, the overproduction compared to the benchmark open-loop case is higher. Consequently, firms prefer the open-loop to the feedback, and the feedback to the closed-loop equilibrium.

Under static solution concepts, rebate contracts simply shift prices and leave prices net of rebates unaffected. Under dynamic solution concepts however, prices and quantities in equilibrium depend on rebates granted. Increasing rebates lead to higher quantities and prices in equilibrium. However, the effective prices net of rebates decrease with increasing rebates granted. With increasing rebates, the differences in prices (net of rebates) and quantities between the three dynamic solution concepts vanish. In the limit prices net of rebates under the three dynamic solution concepts coincide and converge to prices under perfect competition.

As we have presented in our analysis, rebates are a useful way to reduce prices in equilibrium and thereby save costs in the health care system. However, based on these findings, we show that dynamic solution concepts are more appropriate to explain the effects of rebate contracts than static ones. This is of particular interest as rebate contracts are used as an instrument to influence market outcomes. To better calibrate their effects, dynamic solution concepts should also be taken into account.

As well as different mathematical aspects that have to be considered, our findings have to be interpreted against the background of the complex real world. In our model we did not assume any fix costs, although in the pharmaceutical industry these are typically rather high. However, as rebates drive down prices rather fast, they might also lead to firms leaving the market, which leaves space for further research.

Another simplifying aspect of our model is the use of identical rebates for both of the two manufacturers. For legally fixed rebates, identical ones are a plausible assumption. However, in the case of voluntary ones, they they might well differ between the two manufacturers. Firms could use discounts as an additional decision variable, which should be further analyzed.

Furthermore, our model does not account for demand fluctuations and shocks. In particular, the demand for health care products may change due to seasonal demand fluctuations. In winter it is likely that the demand for a cold remedy will be higher than in summer. Additionally to these predictable variations in demand, there may be shocks due to epidemics. These aspects are not yet covered in our model, but should be further investigated.

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Part II

Tariff Choice in Telecommunications Markets

Chapter 4

Experimental Evidence on Mobile Tariff Choices*

4.1 Introduction

The cell phone telecommunications market in Germany is characterized by fierce competition among the four network operators T-Mobile, Vodafone, E-Plus and O_2. Although the German market is nearly saturated, the penetration rates are still increasing. Statistically every German possesses 1.3 cell phone contracts today. This development is mainly driven by continuous price cuts, particularly by discount offers (Bundesnetzagentur (2009)). Hence, the average revenues per subscriber (ARPU) are decreasing and have declined by approximately 40 percent between 2003 and 2010 (Merril Lynch (2010)). Thus, new tariff structures become necessary for the network operators to stay profitable.

In Germany, cell phone tariffs consist of three main components: monthly subscription fees, different usage prices and payments for handsets. Traditionally, the cell phone operators used to sell cell phones with huge discounts in order to accelerate the adoption of their services. However, as penetration rates are now over 100 percent, acquiring new customers is not very lucrative and therefore handset subsidies are very costly for the operators (Kruse et al. (2004)). Smaller providers especially face high average costs due to lower capacity utilization, caused by

*The research of this chapter is part of a joint project with Anne-Kathrin Barth.

fewer subscribers and lower voice volumes. Hence, E-Plus and O_2 started to offer tariffs which do not include the corresponding cell phone. The cell phone can either be paid at once or via deferred payments with low, or even no, interest payments. To still attract consumers, the usage prices of the new tariffs are reduced compared to their competitors. In contrast to the small providers, the first-movers T-Mobile and Vodafone, who still account for 65 percent of the market (Bundesnetzagentur (2009)), continue to subsidize cell phones. Overall, many different tariff structures are offered for similar cell phones. In 2010 or instance, the handset price for the iPhone 4 (16 GB) varies between 1 Euro and 649 Euro depending on the other tariff components and the operator.

Based on marketing science and behavioral economics, we know that many consumers in cellular telecommunications choose calling plans that are not always cost-minimizing (e.g., Bolle and Heimel (2005), Lambrecht and Skiera (2006)). In this chapter, we examine how consumers decide between cell phone tariffs with different contract components. Therefore, we run an experiment with students and staff of the Heinrich-Heine-University of Düsseldorf and test for preferences in selecting cell phone contracts. Abstracting from demand uncertainty and preferences regarding service quality, brand images of operators and network externalities, our focus lies on the choice between contracts with handset subsidies, direct purchase or deferred payments for the cell phone.

Within the tariff choices, we find different explanations for irrational decisions. Observing that respondents often estimate their consumption incorrectly, they are likely to choose cost-dominated tariffs. On the other hand, they are generally able and willing to detect cost-minimizing tariffs. Furthermore, with increasing usage level, consumers' performance improves. However, some participants hold preferences for certain tariff forms, inducing them to choose cost-dominated offers.

The chapter is organized as follows: The next chapter, 4.2, provides an overview of the theoretical background and we derive five testable hypothesis. Chapter 4.3 explains our experimental design and procedure. Chapter 4.4 summarizes our descriptive and empirical results. Finally, chapter 4.5 concludes and provides policy implications.

4.2 Related Literature and Hypothesis

According to traditional economic theory, consumers are assumed to be rational utility maximizers. However, various articles in the field of behavioral economics show that consumers take irrational decisions, violating the expected utility hypothesis. The theory of bounded rationality, such as in the versions of Simon (1957), Kahneman and Tversky (1979) and Gigerenzer and Selten (2002), incorporates psychological research into economic theory. It introduces several important concepts into the environment of choices under risk, e.g., loss aversion and the shape of the probability weighting function.

In a telecommunications setup, certain aspects of irrational behavior are of interest. In order to detect the right calling plan and maximize the expected utility, consumers have to be aware of their actual and future consumption. Several authors, like Mitchell and Vogelsang (1991), Taylor (1994) and Nunes (2000), state that consumers are not aware of their actual consumption and quite inaccurate in predicting their future usage. In line with Miravete (2003), we assume a range of ±20 percent, regarding the estimation of the average consumption. Based on these findings, we derive hypothesis H_1 as potential reason for irrational tariff choices:

H_1: Consumers face difficulties estimating their consumption correctly within a range of ±20 percent.

Facing a tariff decision, consumers are confronted with a considerable number of alternatives, comprising many different parameters. In our setup, the number of relevant parameters is reduced to three. Nevertheless, participants could still face difficulties due to lacking mathematical abilities. Even if consumers have the ability to analytically derive the optimal tariff, they might still not be willing to do so. Morwitz et al. (1998) and Hossain and Morgan (2006) test whether consumers account for total costs, including, for example, costs for shipping and handling, or just stick to the base price. They find that consumers are often not motivated to perform these calculations properly and hence make suboptimal decisions. In our setup, this implies that participants possibly do not account for all parameters. Both arguments are summarized in H_2:

H_2: Consumers are unable to find the cost-minimizing tariff.

Additionally, consumers may find it hard to cope with telecommunication-specific aspects, such as a cell phone bill. Not all cell phone subscribers are familiar with the interpretation of billing increments. This ability is tested by H_3:

H_3: When faced with a cell phone bill, consumers make more decision errors than when they are given a certain usage level.

Selecting tariffs, consumers' usage levels play a decisive role for their performance. If consumption is low, the cost differences between optimal and non-optimal tariffs are relatively small. According to Clay et al. (1992) and Srinagesh (1992), these minor cost differences in particular induce careless behavior in consumers. This is also confirmed by Miravete (2003) who finds that households with lower consumption perform worse than those with higher usage. With H_4, we verify if these results are also true in our experimental setup.

H_4: Low volume users are more likely to opt for cost-dominated tariffs than high volume users.

In addition to these more general causes for irrational choices, this chapter investigates consumers' preferences for different payment forms, including deferred payments. Various articles have been published to date, dealing with irrational behavior in the telecommunication context. One strand of literature covers consumers' choice between flat rate tariffs and pay-per-use tariffs. Lambrecht and Skiera (2006), Gerpott (2009) and Mitomo et al. (2009) detect in their experiments a sustainable flat-rate bias, leading to consumers choosing flat rate tariffs even though pay-per-use tariffs would yield lower invoices. Bolle and Heimel (2005) and Haucap and Heimeshoff (2011) check for irrational decisions in the context of on-net and off-net calls and Krämer and Wiewiorra (2010) analyze cell phone tariffs with cost caps. In line with these papers, we assume consumers hold preferences for different payment forms. These considerations are crucial in our model, in which total costs are the only decision parameter. Hence, any deviation from the calling plan with the lowest overall expenditures can be classified as irrational choice, leading to H_5:

H_5: Consumers have preferences for tariffs including handset subsidies.

Although various aspects of cell phone tariffs have already been studied, as far as we know tariff choice in the context of subsidies has not been analyzed. The next chapter explains our experimental design and procedure.

4.3 Empirical Design and Procedure

Our experiment is structured in three distinct parts.[3] In the first part, respondents are asked to estimate their average monthly consumption in terms of outgoing minutes. This estimation is compared to the average usage of their last three cell phone bills. If the participants estimate their consumption correctly, meaning within a range of ±20 percent, they receive an extra payment of 1000 taler.[4]

In the second part of the experiment, participants are randomly assigned to the groups A, B, C and D, which are almost equally large. They are incentivized to take cost-minimizing decisions as they are equipped with a certain amount of money, which is consequently reduced by the costs for the tariffs they choose.[5]

This second part consists of 10 tariff choices. To control for different billing formats, the 10 choices are subdivided into two rounds of five choices each.[6] In round 1, participants are told to assume a particular, fixed average of monthly outgoing minutes (either 25 min., or 70 min., or 120 min., or 200 min.) and take it as given throughout the next five decisions (choices 1 to 5).[7] The second five questions (choices 6 to 10) are composed in the same way as the first five questions. However, in the second round participants have to calculate their average monthly outgoing minutes themselves. A fictional cell phone bill is handed out and participants are told to take it as representative of their monthly consumption during choices 6 to 10. The fictional bills are composed so that they again display either

[3] See Appendix at the end of this chapter for further information.

[4] 1000 taler $\hat{=}$ 1 Euro.

[5] Group A and C receive 19000 taler and group B and D receive 24000 taler, respectively. The endowments differ to ensure that, irrespective of the group, participants may achieve identical earnings.

[6] Usually, cell phone operators only list the outgoing calls and minutes on the cell phone bill, but some also provide the total amount of outgoing minutes.

[7] By the end of 2009, the market share weighted average of outgoing cell phone minutes per subscriber was 124 minutes/month in Germany (Merrill Lynch (2010)). Therefore, our four groups represent realistic cases for low, medium and high cell phone usage.

a 25 min., 70 min., 120 min., or 200 min. monthly usage. Those participants, who base their choices on 25 min. in the first round, are confronted with a cell phone bill of 120 min. in the second round and vice versa. Those who start with a 70 min. usage in round 1, receive a 200 min. bill in the second choice scenario, and vice versa. Figure 4.1 illustrates the design of our experiment.

Figure 4.1: Design of the Experiment

Group	Choices									
	Round 1: Given usage					Round 2: Usage derived from fictional bill				
	1	2	3	4	5	6	7	8	9	10
A	25 min.					120 min.				
B	70 min.					200 min.				
C	120 min.					25 min.				
D	200 min.					70 min.				

Based on their usage, participants are asked to select their optimal tariff out of three given tariffs (T1, T2 and T3). All three tariffs include an identical cell phone and run for 24 months. Each tariff comprises a price for the cell phone, a monthly subscription fee and a charge per minute for outgoing calls, irrespective of calling on-net or off-net (i.e., fixed-line or other cell phone networks). All 10 choices are of the following representative form:

Decision: As your former cell phone contract has run out, you have the chance to choose between the following tariffs:

T1: Price for the cell phone = X_{T1} taler, monthly subscription fee = Y_{T1} taler, price per minute for outgoing calls = Z_{T1} taler.

T2: Price for the cell phone = X_{T2} taler, monthly subscription fee = Y_{T2} taler, price per minute for outgoing calls = Z_{T2} taler.

T3: Price for the cell phone = X_{T3} taler, monthly subscription fee = Y_{T3} taler, price per minute for outgoing calls = Z_{T3} taler.

The setup of our experiment is summarized in the following Table 4.1. Part 2 explains the composition of the 5 different questions (choices 1-5 and 6-10, respectively). The first two decisions of each round test participants' logical understanding of the experiment and are intended to familiarize them with our experimental design. The other three scenarios control for respondents' tariff preferences regarding different handset payment options. In general, three different tariff concepts can be distinguished. Consumers can choose between tariffs including a buy now option, a hire-purchase alternative and a handset subsidy. Consumers may either purchase the handset immediately at contract formation (buy now option), or pay the handset price via monthly installments (hire-purchase option). For these two varieties all other tariff components are identical, except for the monthly fixed fees. Contracts with handset subsidies contain no or low expenditures for the handset, as they are included in the relatively high cost of usage.

Table 4.1: Experimental Setup

Part 1	Estimation of average monthly consumption	
Part 2	Tariff choices	
	Choice 1(6) & Choice 2(7)	Choice 3(8)
T1	Logical understanding &	Handset subsidy
T2	familiarization with	Buy now option
T3	experimental design	Hire-purchase option (no mark-up)
	Choice 4 (9)	Choice 5(10)
T1	Handset subsidy	Handset subsidy
T2	Hire-purchase option (no mark-up)	Hire-purchase option (with mark-up)
T3	Buy now option	Buy now option
Part 3	Questionnaire on personal characteristics	

In the third part, participants are asked to give detailed information on personal characteristics (e.g., age, gender, course of studies) and their calling behavior (e.g., prepaid contract, provider changes). The final question tests which tariff they have chosen, if they were indifferent between two or three options (e.g., being listed first, lowest monthly subscription fee).

We invited a total of 87 students and staff members of the Heinrich-Heine-University of Düsseldorf to our experiment via ORSEE. Participants were asked to bring their last three cell phone bills for which they received three euros extra. 27 out of 87 participants brought the requested bills along. However, 31 respondents are prepaid customers and thus do not receive monthly bills at all. All respondents (52 percent female) use cell phones, and the average age was 25.6 years. The market shares of the providers E-Plus (38 percent), O_2 (29 percent), Vodafone (20 percent) and T-Mobile (14 percent) differ from the real market situation in Germany, where T-Mobile and Vodafone hold 36.3 percent and 32.1 percent of the market share respectively. In addition, E-Plus and O_2 serve 17.3 percent and 14.2 percent respectively of all customers (Bundesnetzagentur (2009)). The differences in the operators' market shares can be explained by the fact that the participants were mostly students, who are more likely to be E-net customers due to lower price offers.[8] Around 81 percent of the participants are very satisfied or satisfied with their provider, and 36 percent of our respondents have switched their provider within the last two years.[9] This churn rate is relatively high compared to the findings of a study on consumers' switching behavior (EU Commission (2009)). Our descriptive and empirical results are discussed in the next section, 4.4.

4.4 Results

4.4.1 Descriptive Results

First, we investigate the degree to which the participants in our sample know their average monthly consumption in terms of outgoing minutes. In line with H_1, we find that about 82 percent of the participants who brought their bills, do not estimate their actual usage correctly. Approximately 40 percent of the participants overestimate and around 60 percent underestimate their average use. Another interesting fact is that the average prediction error is around 444 min. for the respondents who overestimate and only around 133 min. for the participants who underestimate their real consumption. This indicates that the prediction bias is roughly three-times as large for those who overestimate their consumption. Al-

[8]E-Plus and O_2 operate in the frequency range of 1800 MHz (E-net), whereas T-Mobile and Vodafone use the frequency range of 900 MHz (D-net).

[9]Additional information regarding the descriptive statistics can be found in Table 4.4 in the Appendix at the end of this chapter.

though fewer participants overestimate their consumption, the average amount to which they overestimate their consumption is much higher. Hence, it is likely that consumers do not choose cost-minimizing tariffs, leading to systematic errors. These findings are in line with the growing literature related to flat-rate biases (e.g., Lambrecht and Skiera (2006) and Gerpott (2009)).

Finding the cost-minimizing cell phone tariff involves some calculations. Based on the questions testing their ability and willingness to perform the calculations correctly, H_2 has to be rejected. In our dataset only two of the 87 participants repeatedly selected cost-dominated tariffs in the questions targeting the logical understanding of the experiment (choice 1, 2, 6 and 7). Additionally, from our final question regarding indifference about different payment forms, we infer that only around 3.4 percent of the respondents choose tariffs because they are listed first. We conclude that non-optimal choices are not caused by lack of understanding or motivation. However, we offered the participants very stylized forms of cell phone tariffs, containing only three variables. In reality, consumers are confronted with a lot more criteria, e.g., different prices for on-net and off-net calls and prices for text messages. Therefore, the increasing complexity might in fact support H_2.

H_3 suggests that participants face difficulties analyzing cell phone bills. In order to test H_3, we compare the answers given in the first round for a specific, fixed usage (25, 70, 120 or 200 min.) to the choices in the second round. The two rounds only differ in the format in which the average monthly consumption is presented. In the first round it is given, whereas in the second round participants have to perform calculations themselves. By applying a two-sample Kolmogorov-Smirnov test for all corresponding questions and groups, we cannot reject the null hypothesis, stating that the distributions are equal.[10] We conclude that there are no differences in the distributions between the first and the second round for any usage type. Hence, H_3 has to be rejected, indicating that respondents are able to interpret a representative monthly bill.

[10] A two-sample K-S test tests for the equality of distributions between two groups. The distribution of each choice for group A is compared with that of the group C, and group B is compared to group D. For example, we first merge the results of question 3 for group A with the results of question 8 of group C, both including a usage of 25 min./month. Subsequently, we determine if there are any differences in the distribution between group A and C (for further information see Büning and Trenkler (1994)). All K-S tests are summarized in Table 4.7 in the Appendix at the end of this chapter.

Based on the results stated above, we match all groups with the same average monthly consumption, irrespective of the two rounds. For example, the results of questions 1 to 5 of group A are combined with the answers to questions 6 to 10 of group C. This process reduces the number of choices to five, labeled 1^* to 5^*. Figure 4.2 illustrates the reduced setup.

Figure 4.2: Reduced Setup

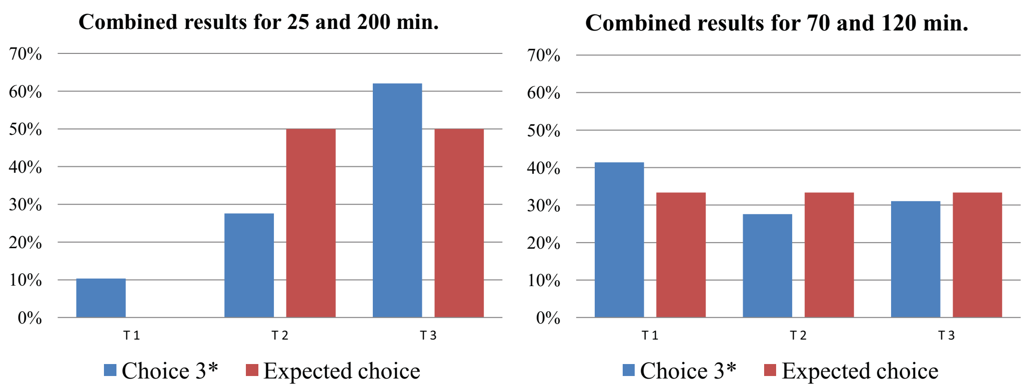
	Choices				
Group	**1***	**2***	**3***	**4***	**5***
A + C			**25 min.**		
B + D			**70 min.**		
C + A			**120 min.**		
D + B			**200 min.**		

H_4 assumes differences in the performance between low- and high-volume users. The main explanation is that higher consumption increases the cost differences between optimal and non-optimal tariffs. Hence, high-volume users have, in general, stronger incentives to subscribe to the cost-optimal tariff. In our experiment, participants on average select cost-dominated tariffs in around 3.2 percent of all choices. The participants of group A and C make a mistake in around 3.5 percent of all questions on average, whereas the respondents of group B and D fail in around 2.9 percent of all choices. These first results support H_4, as the total usage of group A and C is lower than for group B and D. For an in depth investigation, we compare the average error for the lowest and the highest assumed usage, based on the reduced setup. For 25 min., participants make, on average, errors in 3.9 percent of all choices, compared to 2.9 percent, when assuming a 200 min. usage. Despite of a higher error rate, lowest volume users spend, on average, 67.3 taler too much, compared to 117.9 taler for maximum volume users. We conclude that in line with H_4, high-users are disciplined and more likely to opt for the cost-minimizing tariff.

As already mentioned above, cell phone tariffs in our experiment consist of, and vary in, the following price components: monthly subscription fees, usage-dependent prices and handset payments. H_5 states that consumers have preferences for specific cell phone tariff forms. Preferences for some tariff forms are tested by question 3*, 4* and 5*.

First, we look at choice 3* with the possible choices: tariff with a handset subsidy (T1), a buy now option (T2) and a hire-purchase option with zero interest rate (T3). In the case of 25 min. or 200 min. average monthly usage, the tariffs T2 and T3 both minimize costs. Thus, we would expect the two options to be chosen equally often. For 70 min. or 120 min. consumption, the tariffs T1, T2 and T3 yield equal payments and an even distribution between the three tariff forms would be likely. Based on identical rational options, the results for 25 min. and 200 min., and 70 min. and 120 min. are grouped and compared to the expected, cost-minimizing tariff choices.

Figure 4.3: Choice 3* - Realized Choices differ from Expected Choices



The left side of Figure 4.3 shows the results for the 25 min. and 200 min. usage. T1 is chosen by 9 participants, compared to 24 participants who choose T2 and 54 respondents who vote for T3. This highlights two different aspects. Comparing the two cost-minimizing choices, rational participants seem to prefer the hire-purchase option (T3) over the buy now option (T2). In our experiment, they possess enough money to select either alternative; however respondents might have in mind their real financial background, leading to the preferences for the hire-purchase option. The second insight is that even though the alternative T1 (handset subsidy) is cost-dominated, it is chosen by about 10 percent of the respondents. This indicates that some participants have a bias towards the cost-dominated tariff T1, including a handset subsidy. Looking at the usage types separately, we find that about 14.6 percent in the 25 min. and only about 6.5 percent in the 200 min. usage group select the more expensive T1. This again supports H_4.

The preference for subsidies is also confirmed by the results presented on the right side of Figure 4.3. Although all three tariffs are rational in this setup, the distribution of the given answers differs from the expected one. 36 participants opt for T1, while 24 choose T2 and 27 respondents T3. Hence, the distribution is shifted in favor of the handset subsidy tariff.

Applying chi-square goodness of fit tests, we find that the observed choices are significantly different (p-value = 0.0007) from the expected ones for the 25 min. and 200 min. usage.[11] In contrast, for 70 min. and 120 min., the null hypothesis that each option is chosen equally often cannot be rejected (p-value = 0.2605).

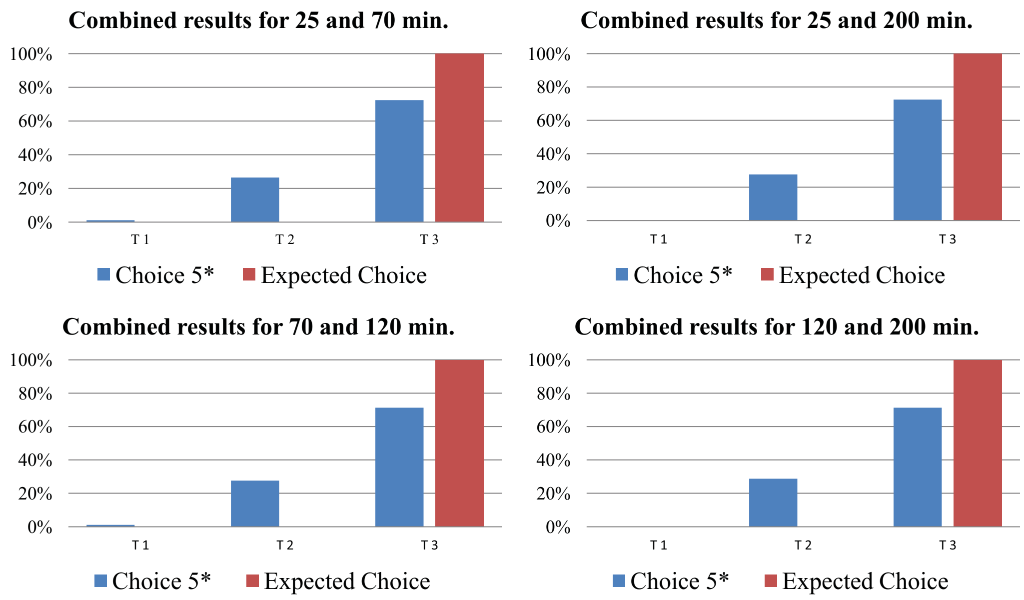
Question 4* is constructed similarly to question 3*, but on a higher cost level. We find identical choice patterns. However, with increasing tariff cost, even more participants tend to prefer the option with a handset subsidy, yielding lower down-payments.

In question 5* we introduce higher costs for the hire-purchase option in comparison to the buy now option. Additionally, we rearrange the tariff choices to avoid habituation effects. Participants can choose between a tariff with a handset subsidy (T1), a hire-purchase option with a positive mark-up (T2) and a buy now option (T3). The buy now option dominates for all usage groups. Figure 4.4 illustrates our results.

For the combined usage of 25 min. and 70 min., 1 participant chooses T1, while 23 participants pick T2 and 63 respondents choose T3. Looking at the combined usage of 25 min. and 200 min., we find that 0 participants choose T1, 24 choose T2 and 63 respondents pick T3. Similarly, for the combined usage of 70 min. and 120 min., 1 respondent opts for T1, 24 respondents for T2 and 62 participants for T3. For the combined usage of 120 min. and 200 min., 0 participants chose T1, 25 pick T2 and 62 participants choose T3. We find that for all possible usage combinations about 30 percent of the participants prefer the hire-purchase option

[11] A chi-square goodness of fit test tests whether the observed percentages for a categorical variable are significantly different from the expected percentages. For further information see Büning and Trenkler (1994).

Figure 4.4: Choice 5* - Realized Choices differ from Expected Choices



over the direct purchase, even if they incur a 1 percent loss due to higher costs. Applying once more chi-square goodness of fit test for all usage combinations, we find that for all cases the observed choices are significantly different from the expected ones, all on a 5 percent significance level or higher.

Compared to the results of question 3* for a 25 min. and a 200 min. usage, the handset subsidy option is no longer chosen. Being in group 25 min. (200 min.) and selecting the handset subsidy tariff causes additional costs of 60 taler (840 taler) in question 3* and 360 taler (1200 taler) in question 5*. Consequently, consumers hold preferences for the handset subsidy option (T1), but do not realize them if they are too costly. The same holds true for the preferences for the hire-purchase option over the direct purchase. However, relatively low cost differences and thus realizing losses in question 5*, do not prevent them from choosing this option. To sum up: Consumers are biased in favor of the handset subsidy and the hire-purchase options, but only up to an individual limit. If costs for the preferred option exceed this certain threshold, consumers select the cost-minimizing tariff.

If we look separately at the different usage types, we find again that low user are more likely to choose non-minimizing tariffs due to smaller costs differences than high users. These results show again evidence in favor of H_4.

In the next chapter, 4.4.2, we empirically analyze the tariff selection in more detail. We want to investigate which characteristics influence the likelihood of rational behavior by applying probit and logit regressions.

4.4.2 Estimation Results

In this subsection, we focus on questions 3^* and 5^*. From question 3^*, we aim to empirically explore which factors drive the probability of choosing the hire-purchase option over the direct purchase if the two options are equally priced. With question 5^*, we investigate which factors influence the probability of choosing the cost-minimizing buy now option.

First, we look at choice 3^* in more detail. As explained above, we can only compare the variants 25 min. and 200 min. and variants 70 min. and 120 min. due to differing optimal answers. For 25 min. and 200 min., T2 and T3 are optimal. As presented in Figure 4.3, the hire-purchase option (T3) seems to be preferred over the direct purchase of the handset (T2). Therefore, we wish to determine which characteristics influence the likelihood of selecting the hire-purchase option, taking only the rational consumers into considerations. As we do not consider 9 participants, who irrationally chose T1, the number of our observations drops to 78. All 78 observations are independent, as we merge only the results of different usage levels of different participants.

Our explanatory variables contain information on age, and the time needed to take a decision. In addition, we include dummies to control for personal characteristics. We distinguish whether a person is female ($female$), a prepaid customer ($prepaid$), an economics student ($econ$), a frequent mobile internet user ($mobint_{high}$), a E-net customer ($enet$), satisfied with her current net provider ($satisfied_{high}$), and if she has switched the provider within the last two years ($switched$). Furthermore, we include a group dummy equal to 1, if a respondent is in group A or C. Here, $group_{AC}$ indicates a 25 min. usage. Our results are presented in Table 4.2.[12]

[12] A detailed description of all relevant variables can be found in Table 4.5 in the Appendix at the end of this chapter.

Table 4.2: Choice 3* for 25 min. and 200 min.

Variable	Probit	Logit
Dep. Var.	Hire-purchase option	
age	0.0042	0.0034
	(0.0077)	(0.0082)
time	0.0001	0.0002
	(0.0008)	(0.0008)
female	0.1969*	0.2053*
	(0.1175)	(0.1182)
prepaid	-0.1732	-0.1896
	(0.1362)	(0.1501)
econ	0.1978*	0.1811*
	(0.1092)	(0.1111)
$mobint_{high}$	-0.2360	-0.2534
	(0.1526)	(0.1702)
enet	-0.0009	-0.0126
	(0.1241)	(0.1320)
$satisfied_{high}$	-0.0352	-0.0451
	(0.1684)	(0.1729)
switched	0.1210	0.1081
	(0.1084)	(0.1117)
groupAC	-0.2259*	-0.2345*
	(0.1195)	(0.1293)
N	78	78
$PseudoR^2$	0.1357	0.1354

*,**,*** indicate statistically significant on the 10%, 5%, and 1% level
Results are already transformed to marginal effects
Heteroscedasticity robust standard errors in parenthesis

Focusing on the probit regression, we find that our discrete variables $female$ and *econ* both have a significant and positive influence on the likelihood of choosing the hire-purchase option. Furthermore, $group_{AC}$ has a significant, but negative effect.

As we have reported marginal effects in Table 4.2 for the probit regression, we can directly interpret these effects: The probability of selecting the hire-purchase option is 0.1969 higher if a subject is $female$. Additionally, the probability of choosing T3 increases by 0.1978, if the person studies economics or business administration. Although there is no monetary difference between the two tariffs in our experiment, this might be explained by the discounting theory learned during the first semesters. For those participants who assume a 25 min. usage, the likelihood of selecting the hire-purchase option is reduced by 0.2259. Our results are also robust applying logit regression. Around 13.5 percent of the total variation is explained by our model. A drawback is that all three variables are only significant at a 10 percent significance level.

Analyzing choice 3* for the variants 70 min. and 120 min., we do not find any significant effects indicating which variables determine the preferences for a specific tariff option. This is not very surprising, as we already see in Figure 4.3 that the variation between the three tariff options very small.

In addition, we examine choice 5*, where we have included a mark-up of about 1 percent for the hire-purchase option over the direct purchase. In this setup, it is rational to choose the buy now option for all given usage types. Again, all 87 observations are independent, as we merge only the results of different usage levels. Table 4.3 summarizes our empirical results for the representative 25 min. and 200 min. usage.[13]

Regarding the probit regression, the variables *age* and *enet* both have a negative, but highly significant effect on the likelihood of choosing the direct purchase option, while *time* and $satisfied_{high}$ both have a positive influence at a 5 percent significance level or higher. The probability of selecting the direct purchase option decreases by 0.0239 per year of age. Being an E-net customer reduces the likelihood of choosing T3 by 0.2377. The reason might be that price-sensitive

[13]The probit estimations for all other possible usage combinations can be found in Table 4.6 in the Appendix at the end of this chapter.

Table 4.3: Choice 5* for 25 min. and 200 min.

Variable	Probit	Logit
Dep. Var.	Buy now option	
age	-0.0239***	-0.0223***
	(0.0066)	(0.0068)
time	0.0039***	0.0036**
	(0.0013)	(0.0015)
female	-0.1311	-0.1305
	(0.0964)	(0.0971)
prepaid	-0.0747	-0.0690
	(0.1044)	(0.1022)
econ	0.0570	0.0432
	(0.1134)	(0.1128)
$mobint_{high}$	-0.0357	-0.0215
	(0.1147)	(0.1113)
enet	-0.2377***	-0.2366***
	(0.0900)	(0.0943)
$satisfied_{high}$	0.3498**	0.3595**
	(0.1594)	(0.1666)
switched	0.0350	0.0259
	(0.0969)	(0.0988)
groupAC	0.0054	0.0099
	(0.1022)	(0.1029)
N	87	87
$PseudoR^2$	0.2840	0.2779

*,**,*** indicate statistically significant on the 10%, 5%, and 1% level
Results are already transformed to marginal effects
Heteroscedasticity robust standard errors in parenthesis

E-net customers are deterred by the high direct payment of T3. Those participants who take more time to make a decision are more likely to opt for the rational tariff, although the magnitude is, at 0.0039, rather small. Being satisfied with their mobile operator increases the probability of selecting T3 by 0.3498. Moreover, 28.4 percent of the total variation is explained by our model. All aspects considered, the findings suggest that some individual factors shape cell phone tariff choice. Our results are also robust applying logit regression.

In the final section, we summarize our results and discuss resulting policy implications.

4.5 Conclusion

This chapter has analyzed different sources for potential biases in consumers' mobile tariff choices. We detect that consumers are often not aware of their average monthly consumption in terms of outgoing minutes. Recent developments have compounded this problem. According to § 99 of the German Telecommunications Act (TKG), network operators are allowed, but not obliged, to list all outgoing calls covered by a voice flat rate. Recently, some network operators have decided they will no longer publish all calls placed within a flat rate. Thus, consumers may be unable to verify their individual consumption on the basis of their cell phone bill. Contrary to the argumentation of the network operators and the Federal Network Agency, we believe that the existing regulation harms consumers, making it even more difficult for them to find out their monthly consumption.

When confronted with cell phone tariffs, consumers are able to interpret different components. In principle, they know how to find cost-minimizing tariffs. This is also true if the consumption is based on stylized cell phone bills. However, in reality cell phone tariffs are often presented in a rather different way than in our experiment. Consumers have to extract all relevant information from the internet or from brochures for a very large number of tariffs. Additionally, the number of relevant parameters is typically not limited to three. This makes is a lot more difficult for the consumers to come up with the optimal tariff.

In our setup, we find that high-users perform better than respondents with lower consumption levels. Due to larger cost differences between optimal and non-optimal tariffs, high-users are disciplined and more likely to opt for the cost-minimizing tariff.

Consumers seem also to have preferences for certain tariff forms, possibly deterring them from selecting cost-minimizing tariffs. We have shown that consumers hold preferences for subsidies and hire-purchase of cell phones. In one of our setups, about 10 percent select the cost-dominated handset subsidy, indicating a strong bias. Among the two rational payment options for the handset (direct purchase and the hire-purchase), participants clearly prefer the latter.

These findings are also confirmed in a second setup, where around 30 percent of the participants opt for the more expensive hire-purchase tariff.

We infer that the likelihood of choosing the cost-minimizing direct purchase increases if participants are satisfied customers and with the time taken for making a decision. In addition, we find that the probability decreases with age and if a participant is an E-net customer.

Our insights are also of special interest for the telecommunications providers, as they can easily profit from consumers' preferences. In fact, operators seem to exploit existing preferences. For example, T-Mobile and Vodafone continue to subsidize cell phones, whereas O_2 only offers the direct purchase or the hire-purchase of the iPhone. Within O_2 tariffs, the hire-purchase option is interest-free compared to the direct purchase (O_2 (2010), T-Mobile (2010) and Vodafone (2010)). However, it is also possible to buy the iPhone directly via the Apple store, where it is up to 8 percent less expensive compared to the O_2 offers. Still, consumers could prefer purchasing via the operators. Transaction costs might be one explanation and biased preferences for hire-purchases, as we found in our experiment, another.

We have merely presented a first step into the investigation of consumers' preferences for different handset payment forms. While our study has focused on certain special reasons for irrational tariff choices, there may be many more aspects left to analyze. In particular, the flat-rate bias has to be mentioned and kept in mind for a complete analysis. Further work should especially consider potential biases from increasing tariff complexity and the effects of network externalities.

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Appendix

Information on the experiment[14]

Welcome to this decision experiment regarding cell phone tariffs.

Please read the instructions carefully. The entire experiment is anonymous. Throughout the experiment you - as a participant - take the role of a consumer with a given consumption, choosing between different fictitious cell phone tariffs. In the first round, you will be given a precise number of minutes which you use per month. This value is crucial for the choice of tariff. In the second round, you have to calculate your monthly consumption based upon a fictitious representative invoice in order to find the optimal tariff. All cell phone contracts include the following terms:

(i) A contract period of 24 months.

(ii) No cancellation ahead of contract termination.

(iii) Billing increment 60/60 (i.e. every inchoate minutes is counted completely).

Ten decisions are to be made in this experiment in total. Interest rates are not taken into account in this experiment. As supporting tools you may use a pencil, paper and a calculator. A calculator tool can be found at the bottom left of your screen as soon as the experiment starts.

During the experiment you can earn talers depending on your decisions. At the end of the experiment, the gained talers are exchanged at a rate of 1000 talers = 1

[14] This are the instructions group A and C received. The instructions for group B and D only differ in the basic amount of 24000 talers instead of 19000 talers.

Euro and paid out to you. To do so, please wait in your booth until you are called to collect your payment. Please bring all your documents, which you got from us, to the payout after the experiment. You start with a basic amount of 19000 talers (19 Euro). This amount is downsized by your expenses.

The costs of the chosen tariff are drawn off your starting amount after each decision. Please note: Exactly one tariff must be chosen under any circumstance. In the case no tariff has been chosen, the worst tariff is selected for you. You are able to minimize your expenses by your own decision.

Additionally to the experiment, you can earn further 1000 talers by estimating correctly your personal consumption within a range of ±20 percent.

Please note that from now on and during the entire experiment, you must not talk to any other participant. We are forced to call off the experiment, should it happen. Please switch off your cell phones and turn it back on not until the experiment has ended. If there are any questions, please raise your hand and we will come to you.

Instruction[15]

Welcome to this decision experiment regarding cell phone tariffs

Please indicate your average cell phone usage in terms of outgoing minutes per month: My consumption is about _____ outgoing minutes per month.

Round 1

An analysis of your telephony characteristics has shown, that you call with your cell phone 25 minutes a month. The following tariffs apply to the identical cell phone of company X. Decisions 1 - 5 are independent of each other. Please choose exactly one tariff.

Decision 1: As your former cell phone contract has run out, you have the chance to choose between the following tariffs.

[15]This is the instruction group A received. The instructions for group B, C and D display the corresponding averages of monthly outgoing minutes.

T1: Price for the cell phone: = 0 talers, monthly subscription fee = 10 talers, price per minute for outgoing calls = 0.3 talers.

T2: Price for the cell phone: = 0 talers, monthly subscription fee = 10 talers, price per minute for outgoing calls = 1 taler.

T3: Price for the cell phone: = 0 talers, monthly subscription fee = 10 talers, price per minute for outgoing calls = 0.07 talers.

Decision 2: As your former cell phone contract has run out, you have the chance to chose between the following tariffs.

T1: Price for the cell phone: = 50 talers, monthly subscription fee = 10 talers, price per minute for outgoing calls = 0.18 talers.

T2: Price for the cell phone: = 50 talers, monthly subscription fee = 7 talers, price per minute for outgoing calls = 0.3 talers.

T3: Price for the cell phone: = 50 talers, monthly subscription fee = 12 talers, price per minute for outgoing calls = 0.1 talers.

Decision 3: As your former cell phone contract has run out, you have the chance to chose between the following tariffs.

T1: Price for the cell phone: = 0 talers, monthly subscription fee = 10 talers, price per minute for outgoing calls = 0.6 talers.

T2: Price for the cell phone: = 120 talers, monthly subscription fee = 10 talers, price per minute for outgoing calls = 0.3 talers.

T3: Price for the cell phone: = 0 talers, monthly subscription fee = 15 talers, price per minute for outgoing calls = 0.3 talers.

Decision 4: As your former cell phone contract has run out, you have the chance to chose between the following tariffs.

T1: Price for the cell phone: = 0 talers, monthly subscription fee = 50 talers, price per minute for outgoing calls = 0.5 talers.

T2: Price for the cell phone: = 0 talers, monthly subscription fee = 77 talers, price per minute for outgoing calls = 0.275 talers.

T3: Price for the cell phone: = 648 talers, monthly subscription fee = 50 talers, price per minute for outgoing calls = 0.275 talers.

Decision 5: As your former cell phone contract has run out, you have the chance to chose between the following tariffs.

T1: Price for the cell phone: = 0 talers, monthly subscription fee = 30 talers, price per minute for outgoing calls = 0.5 talers.

T2: Price for the cell phone: = 0 talers, monthly subscription fee = 20,25 talers, price per minute for outgoing calls = 0.3 talers.

T3: Price for the cell phone: = 240 talers, monthly subscription fee = 10 talers, price per minute for outgoing calls = 0.3 talers.

Round 2
Two years later your existing contract runs out and you have to choose a new tariff. In your booth, you find a copy of a representative invoice. Determine your consumption and take it as fixed over the next 24 months. The following tariffs apply to the identical cell phone of company X. Decisions 6 - 10 are independent of each other. Please choose exactly one tariff.

Your cell phone invoice:

- Invoice date 10/2010
- Billing Increment 60/60
- Cell phone number: 017xxxxxxxxx
- Total (All numbers in EUR zero - rate VAT) x, xx

Date	Time	Number	Duration
01.10.2010	13:51:40	01604477xxx	00:21:34
04.10.2010	16:32:10	01604477xxx	00:07:49
05.10.2010	18:21:45	01743152xxx	00:04:19
08.10.2010	11:29:10	01743152xxx	00:08:09
09.10.2010	14:58:30	01604477xxx	00:05:48
10.10.2010	11:27:04	01743152xxx	00:03:42
11.10.2010	13:24:00	01693152xxx	00:06:27
13.10.2010	14:57:25	01743152xxx	00:11:20
13.10.2010	14:59:51	01523152xxx	00:02:19
21.10.2010	11:36:13	01743152xxx	00:20:22
27.10.2010	15:41:23	01604477xxx	00:06:16
28.10.2010	22:32:48	01743152xxx	00:02:16
29.10.2010	22:33:57	01743152xxx	00:12:02

Decision 6: With your newly gained insight you now have the chance to choose between the following cell phone tariffs.

T1: Price for the cell phone: = 0 talers, monthly subscription fee = 10 talers, price per minute for outgoing calls = 0.3 talers.

T2: Price for the cell phone: = 0 talers, monthly subscription fee = 10 talers, price per minute for outgoing calls = 1 talers.

T3: Price for the cell phone: = 0 talers, monthly subscription fee = 10 talers, price per minute for outgoing calls = 0.7 talers.

Decision 7: With your newly gained insight you now have the chance to choose between the following cell phone tariffs.

T1: Price for the cell phone: = 50 talers, monthly subscription fee = 10 talers, price per minute for outgoing calls = 0.2 talers.

T2: Price for the cell phone: = 50 talers, monthly subscription fee = 5 talers, price per minute for outgoing calls = 0.225 talers.

T3: Price for the cell phone: = 50 talers, monthly subscription fee = 12 talers, price per minute for outgoing calls = 0.19 talers.

Decision 8: With your newly gained insight you now have the chance to choose between the following cell phone tariffs.

T1: Price for the cell phone: = 0 talers, monthly subscription fee = 12 talers, price per minute for outgoing calls = 0.325 talers.

T2: Price for the cell phone: = 120 talers, monthly subscription fee = 10 talers, price per minute for outgoing calls = 0.3 talers.

T3: Price for the cell phone: = 0 talers, monthly subscription fee = 15 talers, price per minute for outgoing calls = 0.3 talers.

Decision 9: With your newly gained insight you now have the chance to choose between the following cell phone tariffs.

T1: Price for the cell phone: = 0 talers, monthly subscription fee = 50 talers, price per minute for outgoing calls = 0,5 talers.

T2: Price for the cell phone: = 0 talers, monthly subscription fee = 77 talers, price per minute for outgoing calls = 0,275 talers.

T3: Price for the cell phone: = 648 talers, monthly subscription fee = 50 talers, price per minute for outgoing calls = 0,275 talers.

Decision 10: With your newly gained insight you now have the chance to choose between the following cell phone tariffs.

T1: Price for the cell phone: = 0 talers, monthly subscription fee = 30 talers, price per minute for outgoing calls = 0.5 talers.

T2: Price for the cell phone: = 0 talers, monthly subscription fee = 20,25 talers, price per minute for outgoing calls = 0.3 talers.

T3: Price for the cell phone: = 240 talers, monthly subscription fee = 10 talers, price per minute for outgoing calls = 0.3 talers.

Round 3 - Concluding Questions

First of all, we ask you to fill in your personal details. These are dealt with confidentially.

- Age:
- Gender:
- Course of studies:
- Semester:
- Network operator:
- Prepaid contract:
  - Yes
  - No
- Mobile Internet Usage
  - Never
  - Rarely
  - Sometimes
  - Regularly
- Satisfaction with your provider:
  - Very pleased
  - Pleased
  - Less pleased
  - Discontent
- Change of provider within the last two years:
  - Yes
  - No

If you felt that two or more tariffs in this experiment were equally good, which criteria did you employ to decide for one tariff?
I chose the tariff, which

- was in the first place.
- had the lowest device price.
- had the lowest basic charge per month.
- lowest price per minute.
- I never perceived two or more tariffs as equally good.

Thank you for participating in this experiment!

Table 4.4: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
age	87	25.59	7.94	18	56
semester	81	4.65	4.18	1	23
female	87	0.52	0.5	0	1
estimated consumption	87	264.76	519.35	3	3000
real consumption	27	150.86	198.94	3	701
prepaid	87	0.36	0.48	0	1
switched	87	0.36	0.48	0	1
econ	87	0.18	0.39	0	1
$group_{AC}$	87	0.47	0.50	0	1
Network Operator					
T-Mobile	87	0.14	0.35	0	1
Vodafone	87	0.2	0.4	0	1
E-plus	87	0.38	0.49	0	1
o2	87	0.29	0.46	0	1
Mobile Internet Usage					
never	87	0.68	0.47	0	1
rarely	87	0.06	0.23	0	1
sometimes	87	0.09	0.29	0	1
regularly	87	0.17	0.38	0	1
Satisfaction with provider					
very pleased	87	0.21	0.41	0	1
pleased	87	0.6	0.50	0	1
less pleased	87	0.15	0.36	0	1
discontent	87	0.05	0.21	0	1

Table 4.5: Summary Statistics

Variable	Description
age	Age of participant
semester	Semester of participant
time	Time needed to take a single decision
female	Dummy = 1 if a participant is female
prepaid	Dummy = 1 if a participant is a prepaid customer
econ	Dummy = 1 if a participant studies economics or business
$mobint_{high}$	Dummy = 1 if a participant uses mobile Internet sometimes or regularly
enet	Dummy = 1 if a participant is a E-net customer
$satisfied_{high}$	Dummy = 1 if a participant is satisfied or very satisfied with its provider
switched	Dummy = 1 if a participant has switched its provider within the last 2 years
groupAC	Dummy = 1 if a participant is in group A or C

Table 4.6: Choice 5* - for all possible combinations

Variable	$choice5_{25200}$	$choice5_{120200}$	$choice5_{2570}$	$choice5_{70120}$
	Probit			
Dep. Var.	Buy now option			
age	-0.0239***	-0.0242***	-0.0188***	-0.0190***
	(0.0066)	(0.0069)	(0.0065)	(0.0067)
time	0.0039***	0.0043***	0.0025*	0.0031*
	(0.0013)	(0.0014)	(0.0015)	(0.0017)
female	-0.1311	-0.1173	-0.1746*	-0.1488
	(0.0964)	(0.1040)	(0.1008)	(0.1054)
prepaid	-0.0747	0.0993	0.0291	0.1862**
	(0.1044)	(0.0956)	(0.1081)	(0.0956)
econ	0.0570	-0.0100	-0.0031	-0.0622
	(0.1134)	(0.1443)	(0.1316)	(0.1496)
$mobint_{high}$	-0.0357	0.0307	0.0900	0.1615
	(0.1147)	(0.1223)	(0.1103)	(0.1075)
enet	-0.2377***	-0.1953**	-0.1330	-0.0923
	(0.0900)	(0.0999)	(0.1150)	(0.1193)
$satisfied_{high}$	0.3498**	0.3172*	0.1413	0.1239
	(0.1594)	(0.1836)	(0.1607)	(0.1704)
switched	0.0350	-0.2018	0.0419	-0.1855*
	(0.0969)	(0.1104)	(0.0989)	(0.1081)
groupAC	0.0054	0.0362	-0.0036	0.0342
	(0.1022)	(0.1005)	(0.1066)	(0.1020)
N	87	87	87	87
$PseudoR^2$	0.2840	0.2853	0.1540	0.1849

$*, **, ***$ indicate statistically significant on the 10%, 5%, and 1% level
Results are already transformed to marginal effects
Heteroscedasticity robust standard errors in parenthesis

Table 4.7: Two-sample Kolmogorov-Smirnov test for equality of distribution functions for all choices and given usages

Choice 1 - 25 Minutes Usage			
Smaller group	D	P-value	Exact
25	0.0000	1.000	
120	-0.0024	1.000	
Combined K-S	0.0024	1.000	1.000
Choice 2 - 25 Minutes Usage			
Smaller group	D	P-value	Exact
25	0.0405	0.967	
120	-0.0714	0.901	
Combined K-S	0.0714	1.000	1.000
Choice 3 - 25 Minutes Usage			
Smaller group	D	P-value	Exact
25	0.0238	0.988	
120	-0.0071	0.999	
Combined K-S	0.0238	1.000	1.000
Choice 4 - 25 Minutes Usage			
Smaller group	D	P-value	Exact
25	0.0500	0.950	
120	0.0000	1.000	
Combined K-S	0.0500	1.000	1.000
Choice 5 - 25 Minutes Usage			
Smaller group	D	P-value	Exact
25	0.2786	0.204	
120	0.0000	1.000	
Combined K-S	0.2786	0.404	0.306
Choice 1 - 70 Minutes Usage			
Smaller group	D	P-value	Exact
70	0.0000	1.000	
200	0.0000	1.000	
Combined K-S	0.0000	1.000	1.000
Choice 2 - 70 Minutes Usage			
Smaller group	D	P-value	Exact
70	0.0000	1.000	
200	-0.0909	0.827	
Combined K-S	0.0909	1.000	1.000

Choice 3 - 70 Minutes Usage			
Smaller group	D	P-value	Exact
70	0.1174	0.729	
200	0.0000	1.000	
Combined K-S	0.1174	0.997	0.987
Choice 4 - 70 Minutes Usage			
Smaller group	D	P-value	Exact
70	0.0341	0.974	
200	-0.0114	0.997	
Combined K-S	0.0341	1.000	1.000
Choice 5- 70 Minutes Usage			
Smaller group	D	P-value	Exact
70	0.1098	0.758	
200	-0.0417	0.961	
Combined K-S	0.1098	0.999	0.994
Choice 1 - 120 Minutes Usage			
Smaller group	D	P-value	Exact
25	0.0000	1.000	
120	-0.0524	0.945	
Combined K-S	0.0524	1.000	1.000
Choice 2 - 120 Minutes Usage			
Smaller group	D	P-value	Exact
25	0.0500	0.950	
120	-0.1000	0.815	
Combined K-S	0.1000	1.000	1.000
Choice 3 - 120 Minutes Usage			
Smaller group	D	P-value	Exact
25	0.2048	0.424	
120	0.0000	1	
Combined K-S	0.2048	0.784	0.698
Choice 4 - 120 Minutes Usage			
Smaller group	D	P-value	Exact
25	0.2667	0.233	
120	0.0000	1.000	
Combined K-S	0.2667	0.460	0.380
Choice 5 - 120 Minutes Usage			
Smaller group	D	P-value	Exact
25	0.0333	0.977	
120	0.0000	1.000	
Combined K-S	0.0333	1.000	1.000

Choice 1 - 200 Minutes Usage			
Smaller group	D	P-value	Exact
70	0.0000	1.000	
200	-0.0417	0.961	
Combined K-S	0.0417	1.000	1.000
Choice 2 - 200 Minutes Usage			
Smaller group	D	P-value	Exact
70	0.1326	0.668	
200	-0.1212	0.714	
Combined K-S	0.1326	0.988	0.960
Choice 3 - 200 Minutes Usage			
Smaller group	D	P-value	Exact
70	0.1970	0.410	
200	0.0000	1.000	
Combined K-S	0.1970	0.765	0.673
Choice 4 - 200 Minutes Usage			
Smaller group	D	P-value	Exact
70	0.0076	0.999	
200	-0.2045	0.383	
Combined K-S	0.2045	0.723	0.598
Choice 5 - 200 Minutes Usage			
Smaller group	D	P-value	Exact
70	0.0227	0.988	
200	0.0000	1.000	
Combined K-S	0.0227	1.000	1.000

Chapter 5

Conclusion

The following chapter highlights the main findings of this thesis and points to the future research agenda.

Part I addresses different aspects of rebate contracts in the health care sector, both in a static and a dynamic way.

Chapter 2 is entitled **The Effects of Rebate Contracts on the Health Care System** and analyzes the effects of different rebate contract schemes on consumer surplus, firms' profits and total welfare. Depending on the number of rebate contract partners, we differentiate between exclusive (one affiliate) and multiple (two affiliates) rebate contracts. Partially exclusive rebate contracts constitute a third alternative, with one manufacturer being the rebate contract partner. In that case consumers are not obliged to buy the pharmaceutical product under contract, although by not doing so they forgo rebates.

Accounting for vertical and horizontal differentiation, neither multiple nor exclusive nor partially exclusive rebate contracts are favorable irrespective of quality differences concerning consumer surplus. The manufacturers prefer multiple rebate contracts over exclusive rebate contracts. Partially exclusive rebate contracts enable them to further increase profits. Regarding total welfare, the ranking of the different rebate schemes depends on the degree of vertical differentiation.

These findings of our paper are important as they contribute to ongoing discussions in the health care sector. Regarding consumer surplus or total welfare, we do not find arguments supporting the superiority of one of the rebate contract forms.

However, there is very limited data available concerning evidence on the rebate negotiations between GPOs and manufacturers. Consequently, simplifying assumptions were made in our model, which may require further research. The functional form of the rebates granted and the different rebate forms in particular may be updated and elaborated.

In **Chapter 3**, entitled **Rebate Contracts: A Differential-Game Approach**, we present a model of differential games, based on Fershtman and Kamien (1987), Dockner (1988) and Cellini and Lambertini (2004), and introduce rebate contracts. Differently from existing literature on rebate contracts and our findings in Chapter 2, we model a sluggish price adjustment and derive the open-loop, the closed-loop and the feedback solutions.

We also present the static Cournot and perfect competition equilibrium solutions and use them as a benchmark. Under Cournot competition, prices exceed prices derived from the dynamic solution concepts, while quantities are below the corresponding quantities. Conversely, under perfect competition, prices are underrated and quantities overrated compared to the dynamic solution concepts.

However, if either of the firms are myopic or the actual prices do not adjust at all, prices in equilibrium under the open-loop, feedback and closed-loop solution concepts coincide with the prices under perfect competition. For farsighted manufacturers or instantaneous price adjustment, equilibrium prices derived from the open-loop solution are equivalent to prices under Cournot competition. On the contrary, prices under the feedback and closed-loop solutions are lower than Cournot prices.

In our thesis, we find that the subgame perfect closed-loop and feedback solution concepts lead to weakly higher outputs than the weakly time-consistent open-loop solution concepts. The closed-loop solution concept induces higher outputs than the feedback solution concept.

With rising rebates, the differences in prices and quantities between the three dynamic solution concepts decrease, and in the limit prices and quantities are identical and converge to the equilibrium under perfect competition.

Based on our findings, we state that under certain circumstances, dynamic solution concepts may be more appropriate than the static concepts. In particular we find that dynamic solution concepts may explain better the savings caused by rebate contracts.

However, our model also includes some simplifying assumptions. One possibility for further research could be the implementation of demand fluctuations and shocks. Especially in the health care sector, the demand for drugs may vary due to seasonal and epidemic influences. These aspects are not yet covered in our model, but should be further investigated.

Part II focuses on different sources for irrational behavior in consumers' mobile tariff choices.

Chapter 4, entitled **Experimental Evidence on Mobile Tariff Choices**, presents experimental evidence for irrational behavior in the context of cell phone tariff choices. We find that consumers are often not aware of their average monthly consumption in terms of outgoing minutes. In general consumers are able to interpret different components of a stylized cell phone bill. However, in reality the number of relevant parameters is typically not limited to three, as in our experiment, making it much more difficult to extract all relevant information and to find the optimal tariff.

Consumers also seem to hold preferences for certain tariff forms, possibly deterring them from selecting cost-minimizing tariffs. We have shown that consumers hold preferences for subsidies and hire-purchases of cell phones.

Additionally, we infer from our data that the likelihood of choosing the cost-minimizing direct purchase option rises if participants are satisfied with their provider and with the time they take to make a decision. Furthermore, the probability decreases with increasing age of the participants and if a participant is an E-net customer.

Our insights are also of special interest, as operators seem to exploit existing biases. For example, some operators continue to subsidize cell phones, whereas others only offers the direct purchase or the hire-purchase option. Our study has focused on certain special aspects of irrational tariff choices, while others are not directly addressed. The flat-rate bias has to be specially mentioned and kept in mind for a complete analysis. Further research should address factors like the increasing tariff complexity and network externalities.

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