Fixed-Mobile Substitution, Consumer Tariff Choice and Exclusive Dealing:

Four Essays on Telecommunications Economics

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Preface

The research for the present thesis has been conducted at the Duesseldorf Institute for Competition Economics (DICE) at the Heinrich-Heine-University Duesseldorf. The thesis has strongly been influenced by, and benefited from, discussions with professors and colleagues, as well as presentations at various national and international conferences, seminars, and workshops. I am very grateful to all who supported my work in that way. In particular, I would like to thank my supervisor Justus Haucap, Ralf Dewenter and Ulrich Heimeshoff, who encouraged and supported me in various ways. I am also very thankful to Julia Graf for critical remarks, which helped me to improve this thesis in various stages of its development. Finally, I would like to particularly thank my parents, Sigrid and Hans-Peter, for patiently supporting me during the whole time that I was writing this thesis.

Contents

Chapter 1

Introduction

This thesis deals with current aspects of competition, regulation, and consumers' tariff choices in telecommunications markets.

The first part of the thesis (Chapters 2 and 3) analyzes the substitutional relationship between fixed and mobile networks across European countries. Fixed and mobile telecommunication markets are both subject to regulatory obligations, but the magnitude of regulation in the two markets is quite different. Due to bottleneck issues, fixed telephony markets are regulated quite heavily, whereas regulation in cellular markets is less restrictive. The development of the demand for fixed and mobile services raises the question, to what extent are fixed and mobile phones complements or substitutes. If substitutional patterns exist and are significantly large, different regulatory arrangements would be hard to justify.

Chapter 2, entitled **Does the Growth of Mobile Markets Cause the Demise of Fixed Networks? Evidence from the European Union** and coauthored with Ulrich Heimeshoff, analyzes the substitutability between fixed and mobile services on the access level in the European Union by applying Arellano-Bond dynamic panel data techniques. We use a unique dataset which contains information on all 27 European Union members from 2003 to 2009 and estimate own- and cross-price-elasticities of usage prices on the fixed-line and mobile subscription level, respectively. We find strong empirical evidence for substitution from fixed to cellular networks throughout Europe. In addition, the article reveals resulting policy implications.

Chapter 3, entitled **What is the Magnitude of Fixed-Mobile Call Substitution? Empirical Evidence from 16 European Countries** and coauthored with Ulrich Heimeshoff, investigates the degree of fixed-mobile call substitution (FMCS) within different European countries. We use quarterly data from 2004 to mid-2010 on 16 mainly Western European countries. By applying dynamic panel data techniques, we are able to estimate short- and long-run elasticities of the telecommunication usage prices on the fixed-line call demand. The own-price and cross-price elasticities found give strong empirical evidence for substitutional effects towards mobile services. In particular, the estimated cross-price elasticities of the mobile price on the fixed-line call demand are relatively large compared to other studies.

Another recent topic in telecommunications economics is the exclusive distribution of certain mobile devices, e.g. the iPhone from 2007 to 2010, and its effects on consumer welfare. As one of the first, Hermalin and Katz (2010) study exclusive dealing of complementary goods between non-integrated firms and find that exclusive dealing can relax price competition and therefore may reduce consumer welfare. Other authors, such as Chen and Fu (2012), find controversial results.

Therefore, Chapter 4, entitled **Analyzing Competitive Effects of Exclusively Dealt iPhones in European Mobile Markets**, aims at investigating the effects of these exclusive contracts on the level of competition in Europe's mobile markets. We create a unique data set which comprises quarterly information on 55 mobile network operators in 15 European countries between Q4/2003 and Q3/2011. By applying dynamic panel data techniques and controlling for a possible selection bias, we find that the average monthly revenue per subscriber (ARPU) is on average approximately 1.2% higher for an operator engaged in an exclusive arrangement. Thus, our findings indicate that the exclusive rights concerning the iPhone had a strong influence on mobile operators' competition.

Another recent aspect in telecommunications economics concerns innovative tariff structures and consumers' tariff choices. Especially for mobile services, many different tariffs are offered. Based on marketing science and behavioral economics, it is known that many consumers select tariffs that are not always cost-minimizing. Hence Chapter 5, entitled **Irrationality Rings! Experimental Evidence on Mobile Tariff Choices** and coauthored with Julia Graf, investigates how consumers decide between mobile phone tariffs with different contract components and why irrational choices may occur. We run an experiment with 87 members of the Heinrich-Heine University and test for preferences in selecting mobile phone contracts. Abstracting from demand uncertainty and preferences regarding service quality, images of operators and network externalities, our focus lies on the choice between contracts with handset subsidies, direct purchase or deferred payments of the mobile device. Our approach is twofold: first, we account for general difficulties facing a tariff choice, as well as for biased preferences.

To test these hypotheses, our experiment is structured in three distinctive parts. In the first part, participants 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 mobile phone bills. If the participants estimate their consumption correctly, meaning within a range of $\pm 20\%$, they receive an extra payment. The second part of the survey consists of 10 tariff choices. Participants are asked to select their optimal tariff out of three given tariffs. In the third part, participants are asked to give detailed information on personal characteristics and their calling behavior. From our experiment we infer that participants are often not aware of their actual consumption and in line with the findings on flat-rate biases, respondents systematically overestimate their consumption.

The final chapter, Chapter 6, summarizes the central findings and discusses further possible research.

Chapter 2

Does the Growth of Mobile Markets Cause the Demise of Fixed Networks? Evidence from the European Union*

2.1 Introduction

In the beginning of mobile telephony cellular phones were expensive and technically immature products mainly used by business customers who profited most from "being mobile". Almost every outgoing call went to a fixed phone and incoming calls were primarily originated by fixed networks. Hence, the two technologies were seen as complements, meaning that mobile growth also strengthens fixed-line networks (Vogelsang, 2010, p. 5).

After the implementation of GSM digital technology in the early 1990s mobile phones became mass products, demand increased, and prices declined significantly (Hausman, 2002; Gruber, 2005). This trend changed the situation of fixed and mobile markets considerably. Figure 2.1 and 2.2 illustrate the development of the fixed and mobile markets in terms of subscription levels and outgoing voice traffic volumes in the EU27 over time.

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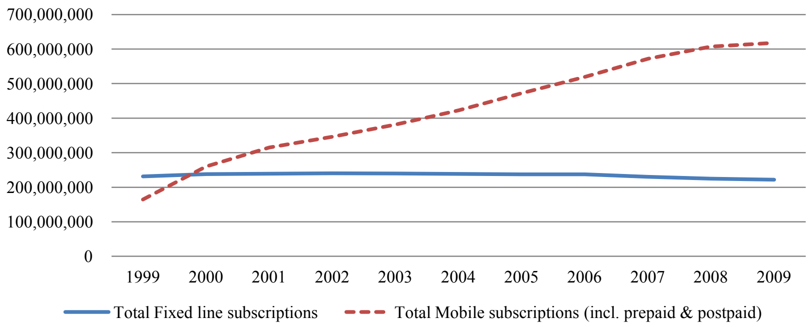
*The research of this chapter is part of a joint project with Ulrich Heimeshoff.

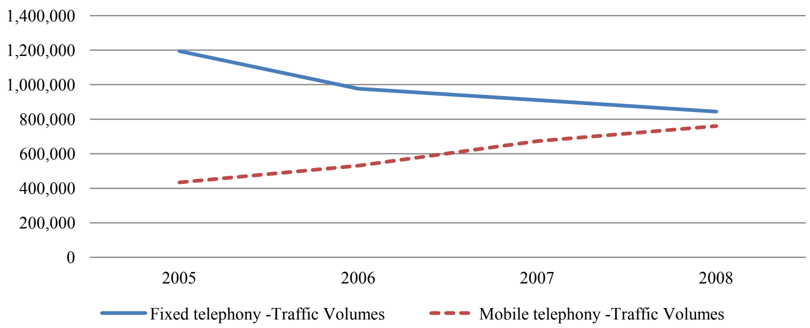
Figure 2.1: Development of fixed and mobile subscriptions (in total)in EU27



Source: ITU, 2010

Figure 2.1 shows that the number of mobile subscribers has exceeded the number of fixed-line subscriptions in the EU27 countries since 2000. While the number of total fixed-line subscriptions stagnates at a level around 200 million users, the number of mobile subscribers has reached 600 million adopters in 2008 and is still increasing (ITU, 2010).

Figure 2.2: Development of fixed and mobile outgoing voice traffic (in million of minutes) in EU27



Source: EU Commission, 2010a

Furthermore, figure 2.2 indicates that the outgoing voice traffic volumes of the fixed and mobile networks are converging, meaning that mobile voice traffic volumes have grown rapidly, whereas fixed traffic volumes went down significantly. Since 2008, the amount of outgoing fixed and mobile voice calls are about the same size, but it is likely that the mobile voice traffic continues to rise and exceeds the fixed voice traffic volumes within the next years (EU Commission, 2010a, p. 26).

Fixed and mobile telecommunication markets are both subject to regulatory obligations (Laffont/Tirole, 2000), but the extent of regulation in the two markets is quite different. Through the liberalization of telecommunications markets in Europe, the former state owned telecommunications companies were (partially) privatized and new competitors were allowed to enter the markets who had to use the incumbent's infrastructure (Cave/Prosperetti, 2001) due to bottleneck issues. Therefore, fixed telephony markets are regulated to a large extent. In contrast, competition in mobile communication markets was fiercer from its very beginning (Haucap, 2003). Hence, regulation in cellular markets has been less restrictive.

The observations of the telecommunications markets in Europe described above lead to the question whether fixed and mobile phones should still be seen as complements or rather as substitutes. If the two services were substitutes, different regulatory arrangements would be hard to justify and the delineation of separate fixed-line and mobile electronic communications markets prescribed in the regulatory framework in Europe might be no longer appropriate. Additionally, new regulatory questions would arise: How should a company be treated that exhibits significant market power in fixed-line telecommunications, but not in mobile communications? What would be the adequate market definition for antitrust and regulation cases?

Although we observe that fixed-line and mobile telephony are converging and becoming closer substitutes, the number of econometric studies has been rather limited. Some first evidence that fixed-mobile substitution is increasing has been provided by Yoon and Song (2003) and Ahn, Lee, and Kim (2004) for Korea and by Rodini, Ward, and Woroch (2003) and Ward and Woroch (2004, 2010) for the USA, by Vagliasindi, Güney, and Taubman (2006) for Eastern Europe, by Heimeshoff (2008) for 30 OECD countries, by Briglauer, Schwarz, and Zulehner (2011) for Austria, and by Ward and Zheng (2012) for China. However, there is virtually no econometric paper analyzing fixed-mobile substitution in a multiple EU country setting. Furthermore, there are only a few studies using recent data, particularly after 2003.

This chapter analyzes the demand for telecommunications services in the member states of the European Union on the subscriber level. Using a dataset which comprises information on all 27 EU countries for the time period from 2003 to 2009, we analyze whether fixed and mobile telecommunications are characterized by a substitutional relationship or not. The main sources of data include the Teligen Reports on Telecoms Price Developments, the Progress Reports on Single European Electronic Communications Markets, the World Development Indicators (WDI), and the ITU World Telecommunication Indicators Database. This chapter is organized as follows: The next section provides an overview of the empirical studies related to fixed-mobile substitution. Afterwards, the dataset used in our empirical study and the econometric approach with respect to panel data are described. The following section 2.3.3 discusses the main findings and section 2.4 concludes.

2.2 Related Literature

Although the analysis of fixed-mobile substitution (FMS) is mainly an empirical question, the related econometric literature is not very extensive. Studies merely exist for South Korea, the USA, Portugal, the UK, and some African and Eastern European countries. In addition, recent papers address FMS in India, Austria, China, Spain and the OECD countries. The following table 2.1 provides an overview of the existing empirical literature.

Using panel data for the period 1991 to 1998 for 8 South Korean provinces, Sung and Lee (2002) find that a 1% increase in the number of mobile phones results in a 0.1-0.2% reduction of fixed-line connections. Thus, they conclude that fixed and mobile telephones are substitutes on Korean telecommunications markets. In more detail, the number of mobile subscribers is positively related with the number of fixed-line disconnections, but negatively related to the number of new fixed-line connections, which suggests net substitution between fixed and mobile services. Yoon and Song (2003) study fixed-mobile substitution in South Korea by analyzing monthly traffic and revenue data from 1997 to 2002. They find that fixed and mobile calls are substitutes and fixed-mobile convergence can be observed in South Korea as in other states of the world. Sung (2003) reports that mobile calls are substitutes for fixed-line toll calls by using Korean regional panel data for 1993 to 1997. Using traffic data from 1996 to 2002 for South Korean telecommunications markets, Ahn et al. (2004) concur with these results. Using South Korean survey data for 2007 and a hierarchical Bayes model for discrete choice data, Rhee/Park (2011) find some evidence for the separation of the fixed-line and mobile telephony markets in South Korea. However, the authors predict that the two markets will converge in the near future as the mobile price premium continues to decrease.

Table 2.1: Empirical Literature on Fixed-Mobile Substitution

Authors	Country/Period
Sung and Lee (2002)	South Korea (1991-1998)
Yoon and Song (2003)	South Korea (1997-2002)
Sung (2003)	South Korea (1993-1997)
Ahn et al. (2004)	South Korea (1996-2002)
Rhee and Park (2011)	South Korea (2007)
Rodini et al. (2003)	USA (2000-2001)
Ward and Woroch (2004)	USA (1999-2001)
Ingraham and Sidak (2004)	USA (1999-2001)
Ward and Woroch (2010)	USA (1999-2001)
Caves (2011)	USA (2001-2007)
Gruber and Verboven (2001)	140 countries (1981-1995)
Barros and Cadima (2000)	Portugal (1981-1999)
Horvath and Maldoom (2002)	UK (1999-2001)
Madden and Coble-Neal (2004)	56 countries (1995-2000)
Hamilton (2003)	25 African countries (1985-1997)
Hodge (2005)	South Africa (1998-2001)
Vagliasindi et al. (2006)	Eastern Europe (2002)
Garbacz and Thompson (2007)	53 LDC (1996-2003)
Heimeshoff (2008)	OECD (1990-2003)
Narayana (2010)	India (2003)
Briglauer et al. (2011)	Austria (2002-2007)
Ward and Zheng (2012)	China (1998-2007)
Suarez and Gracia-Marinoso (2013)	Spain (2004-2009)

Rodini et al. (2003), Ward and Woroch (2004), Ingraham and Sidak (2004), and Ward and Woroch (2010) show the existence of substitutability between fixed and mobile networks in the USA by using the same US survey data for the time period 1999 to 2001. Rodini et al. (2003) analyze the substitutability between fixed and mobile access in the USA modeling the consumers wireless and second fixed-line subscription decision (with logit regressions). They estimate own and cross-price elasticities finding substitution effects. Ward and Woroch (2004) report comparable effects applying the Almost Ideal Demand System-Model (AIDS) (Deaton/Muellbauer, 1980). They conclude that mobile services are substitutes for fixed-line usage at the traffic level, but not at the access level. It should be noted that they only find a moderate degree of substitutability and further empirical evidence is needed to test this hypothesis. Ingraham and Sidak (2004) analyze the effect of long-distance fixed-line call prices on mobile demand and report a small, but highly significant cross-elasticity of +0.022 adopting least squares and 2SLS regression. Ward and Woroch (2010) estimate cross-price elasticities between fixed and mobile subscription by making use of US low-income subsidy programs (Lifeline Assistance) which cause large changes in the fixed-line prices. Although they use the identical US survey data, the elasticities found are larger than those for second lines in Rodini et al. (2003). Due to their ability to generate more price variation by the incorporation of subsidy programs, they are able to estimate demand relationships.

Using US state-level panel data from 2001 to 2007, Caves (2011) estimates single equation models as well as simultaneous equation models for fixed and mobile demand. The author studies wireless and wireline access demand and finds that a one percent decrease in wireless prices results in a 1.2-1.3% decrease in the demand for fixed line services.

Gruber and Verboven (2001) deduce from their study, comprising data of 140 countries from 1981 to 1995, that the diffusion of mobile phones tends to be larger in countries with higher fixed network penetration. Therefore, they conclude that the two technologies are complements. Barros and Cadima (2000) analyze time series data on fixed and mobile access in Portugal from 1981 until 1999. They identify a negative effect of mobile phone diffusion on fixed-line penetration rates, but none vice versa. Horvath and Maldoom (2002) study survey data on over 7,000 British telephone users (repeated cross section in three waves: 1999, 2000, 2001) in a simultaneous equations model and additionally estimate some probit regressions. They induced from their study that using mobile phones decreases fixed-line usage significantly. Their findings support the conclusion that fixed and mobile phones are substitutes in British telecommunications markets. Madden and Coble-Neal (2004) examine FMS in 56 countries between 1995 and 2000 in a dynamic demand model and assess significant substitution effects between mobile and fixed-line subscription rates.

Hamilton (2003) uses annual data from 1985 to 1997 representing 23 African countries. The econometric study shows that fixed and mobile phones in many African countries are still no substitutes. Hamilton argues that the usage of mobile phones does not reduce fixed-line usage, but is primarily an improvement in social status. Compared to studies concentrating on developed countries, these results are not surprising, because in countries that lack an extensive fixed-line infrastructure, like many African and other low developed countries, mobile phone usage is often a result of a lack of supply. In such cases mobile phones are often the only means of access to a telephone.

Using South African survey data from 1998-2001, Hodge (2005) studies how differences in tariff structures between fixed and mobile services have accounted for the popularity of the cellular technology. Hodge finds that in low income households, mobile phones are perceived as substitutes, while in high income households the two services are treated as complements.

Vagliasindi et al. (2006) observe substitutional relationships between fixed and mobile services for Eastern European countries using cross section data for several countries in 2002. In contrast to the other studies, the authors use cross section instead of panel data and cannot control for unobserved heterogeneity. Garbacz and Thompson (2007) analyze FMS in 53 less developed countries (LDC) finding asymmetric substitutional effects. Fixed connections tend to be substitutes in the mobile market, whereas mobile phones might be complements in the fixed-line market. Overall, investigating substitutional effects between fixed and mobile services in transition countries is always difficult as the low quality of fixed networks in these countries often does not allow fixed-mobile substitution. Instead, mobile phones are often the only possibility to receive access to telecommunications.

Heimeshoff (2008) studies FMS on the access level and estimates cross-price elasticities in 30 OECD countries between 1990 and 2003 by using IV estimation. Possible endogeneity problems are solved by instrumenting fixed and mobile

prices and the variable measuring market structure with instrumental variables related to costs and policy indicators. Some sort of one-way substitution is found, i.e. mobile telephony can be a substitute to fixed-line services, but not vice versa. FMS on the subscription level in India is analyzed by Narayana (2010) using cross sectional survey data for 2003. He includes subscription prices as well as usage prices as explanatory variables in his regression and finds that both prices are correlated and that the usage price has, in comparison to the subscription price, a much larger and more significant effect on the mobile and fixed-line subscription. Narayana finds much stronger substitutional effects in both directions than other studies, but uses only cross-sectional data for 2003 and therefore cannot control for unobserved heterogeneity. Employing monthly data on call minutes and taking average revenues per minute as price data, Briglauer et al. (2011) estimate short- and long-run cross-price elasticities for fixed-line domestic calling in response to mobile price changes in Austria for 2002 to 2007. While they observe small and sometimes insignificant estimates for short-run elasticities, their results for long-run cross-price elasticities suggest strong substitution effects.
Ward and Zheng (2012) analyze fixed-mobile access substitution for 31 Chinese provinces from 1998 to 2007. Using Arellano-Bond type linear dynamic panel models, the authors estimate short- and long-run elasticities of the fixed and mobile prices on fixed and mobile subscriptions, respectively and find cross-price elasticities between 0.20 and 0.28 in the short-run and 0.39 and 0.56 in the long-run. In comparison to other empirical studies they find rather strong substitutional effects. Endogeneity problems are dealt with using further lags as well a price related measure like the average Herfindahl index and the fraction of state ownership in fixed and mobile telecommunications for neighboring nearest provinces.
Using quarterly Spanish household survey data for 2004-2009 and logistic regression techniques, Suarez and Garcia-Marinoso (2013) quantify the percentage of households that engage in fixed to mobile access substitution in Spain and the drivers of fixed-mobile access substitution (FMAS). They find the substitutability (0.02% to 0.79% per quarter) to be rather small. The main drivers of FMAS are the availability of Internet and mobile services previous to the substitution decision, socio-demographic characteristics of households, such as age, and the degree and types of expenditure on fixed services.

Next to the papers focusing on the voice substitution, Srinuan et al. (2012) examine Swedish survey data for 2009 and investigate whether fixed and mobile broadband services are complements or substitutes. They find that fixed and mobile broadband technologies are substitutes in most geographical parts of Sweden. Applying logit techniques and including prices for different Internet technologies (DSL, cable, LAN/Fibre and mobile Internet), the authors find that DSL and mobile broadband are more sensitive to price changes than cable and LAN/Fibre, whereas the degree of substitutability varies from area to area.

Beside these econometric studies, some papers of European regulators also discuss the issue of fixed-mobile substitution. Griffith and Dobardziev (2003) conclude for the Netherlands that there already exists some degree of substitutability and this process will proceed as mobile call prices will continue to fall. For Germany, Wengler and Schäfer (2003) evaluate the findings of a telephone survey consisting of 1691 persons (first wave), 2014 persons (second wave) and 101 persons (third wave) collected in March and April 2003. They only observe a very moderate tendency for fixed-mobile substitution in Germany in 2003 and most of the survey participants argue that they do not substitute between their fixed-line and mobile phones. As a consequence, there is no clear empirical evidence what kind of relationship holds between fixed and mobile telephony.

It can be concluded that there are to the best of our knowledge only a few empirical studies on FMAS which use recent data, i.e. data after 2003. It is likely that the substitutional effects of fixed-mobile substitution are much larger nowadays, e.g. due to further price reductions in mobile markets. In addition, it should be noted that there is no multiple country study focusing on fixed-mobile substitution in all 27 EU countries. The following sections provide an overview of the dataset and the applied econometric approach of our empirical study.

2.3 Empirical Specification

2.3.1 Data

We created a unique dataset containing information from 2003 to 2009 on an annual basis. Our data is obtained from the following resources: the Teligen Reports on Telecoms Price Developments, the Progress Reports on Single European Electronic Communications Markets, the ITU World Telecommunications Indicators Database, and the World Development Indicators (WDI). Additionally, the MTR Snapshots of BEREC[1] effects on private access level in all EU member states[2] from 2003 to 2009. Table 2.2 describes all variables used and table 2.3 illustrates its descriptive statistics. fix_{sub} describes the number of total fixed-

Table 2.2: Description of the variables used

Variable	Description of variables
fix_{sub}	Total number of fixed-line subscribers
gdp_{pc}	GDP per capita in Euro PPP
$Internet_{sub}$	Total number of Internet subscribers
mob_{sub}	Total number of mobile subscribers (prepaid + postpaid)
mtr	Mobile termination rates in Euro PPP
p_{fix}	Price of an average fixed-line call in Euro PPP
p_{mob}	Price of an average mobile call in Euro PPP
$perc_{prepaid}$	Percentage of prepaid contracts
$perc_{urban}$	Percentage of urban population
pop	Population
$time$	Linear time trend
$d2003 - d2009$	Time dummies for 2003-2009

line subscribers, whereas mob_{sub} comprises the number of mobile subscribers in an EU27 country including prepaid as well as postpaid subscriptions. p_{mob} represents the average mobile price per call for a given user calculated by using the OECD/Teligen baskets of mobile telephony[3]. p_{fix} is the average fixed-line price per call constructed by using the residential composite OECD basket (2000 version)[4]. Because our price data is based on the OECD/Teligen basket of mobile telephony prices, which is a price basket, we cannot differentiate between prices for access and calls and include them into our regressions separately. The

[1]BEREC stands for Body of European Regulators for Electronic Communications, formerly known as the European Regulators Group for Electronic Communications Networks and Services (ERG).

[2]During the regarded time period new members entered the European Union. Until 2004, the EU consisted of 15 members. In 2004, the EU was enlarged to 25 members. In 2007, Bulgaria and Romania joined the EU.

[3]See appendix for detailed information.

[4]See appendix for detailed information.

OECD/Teligen mobile phone price basket is to best of our knowledge the best price data available for such type of analysis. Both prices, p_{mob} and p_{fix} indicate

Table 2.3: Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
fix_{sub}	189	8,623,152	12,900,000	202,116	54,800,000
gdp_{pc}	189	22,642.14	11,636.47	3432.61	69,334.23
$Internet_{sub}$	178	3,895,888	6,016,454	47,011	34,400,000
mob_{sub}	189	19,000,000	24,900,000	289,992	106,000,000
mtr	185	0.1272	0.0664	0.0218	0.3829
p_{fix}	188	0.3573	0.0998	0.1935	0.6738
p_{moblow}	171	0.5042	0.2339	0.0574	1.1147
p_{mobmed}	171	0.3885	0.1583	0.1008	0.7757
$p_{mobhigh}$	171	0.3386	0.1462	0.0827	0.7215
$perc_{prepaid}$	187	0.5554	0.1911	0.0250	0.9301
$perc_{urban}$	189	0.7128	0.1203	0.4830	0.9738
pop	189	18,200,000	22,600,000	397,399	82,400,000

average prices per call including access as well as usage costs. $Internet_{sub}$ describes the number of fixed-line Internet subscribers (all technologies) and mtr the mobile termination rates. The control variable gdp_{pc} refers to the GDP per capita. pop measures population in a specific country. $Perc_{urban}$ depicts the percentage of the population which lives in urban areas and $perc_{prepaid}$ describes the percentage of prepaid contracts. $Time$ is a linear time trend. The time trend can be interpreted as a constant upgrade in the service quality, the increase in the availability of services, and the enhanced network performance as well as decreasing prices (Grzybowski, 2005). All price variables (p_{mob}, p_{fix}, mtr, gdp_{pc}) and the subscription variables mob_{sub} and fix_{sub} are measured in logarithms in order to interpret them as elasticities. Additionally, all price variables are measured in Euro adjusted by purchasing power parities to add in international comparison. The following subsection explains our model specification.

2.3.2 Model

Fixed-mobile substitution can be analyzed on two different levels: subscribers and traffic (ITU, 2010). To analyze the substitutability between products, usually short- and long-run elasticities are estimated (Taylor, 1994). Such studies belong to the traffic or usage level. However, there is no separate information about traffic data for fixed-line telecommunications available for all EU countries. Instead, we estimate the effects of several explanatory variables, particularly prices and the first lag of the dependent variable, on the stocks of mobile and fixed-line subscriptions. A standard approach to estimate demand equations in telecommunications markets can be derived from the well known Houthakker-Taylor model (Houthakker/Taylor, 1970). The main characteristic of the Houthakker-Taylor model is the inclusion of path dependencies in consumption into the demand equation, which are represented in the demand equation by lagged dependent variables. Taking the panel structure of our data and country specific effects into account, we can derive two adequate specifications. Equation (2.1) and equation (2.2) study the effects of certain variables on the mobile and fixed-line subscription rate, respectively.

$$mob_{sub_{it}} = \beta_1 mob_{sub_{it-1}} + \beta_2 p_{mob_{it}} + \beta_3 p_{mob_{it-1}} + \beta_4 p_{fix_{it-1}} + \sum \beta_k x_{itk} + \alpha_i + \epsilon_{it} \tag{2.1}$$

We expect $mob_{sub_{it-1}}$ to have a positive influence on the current mobile subscription rate for the simple reason that if there were more subscribers yesterday, there will be more subscribers today. Including the first lag of the dependent variable is one way to model the persistence in the subscriber series. Including the first lag refers to the average subscriber in our dataset as all contracts were concluded at different periods in time and include different contract durations. If we would also include the second lag as postpaid contracts usually run for 24 month, the specification would not be suitable on average. Therefore, including only the first lag is the best specification.

We assume that the mobile subscription rate today depends on the current mobile price and its first lag due to different tariff structures in terms of contract durations and subscription fees. Several mobile tariffs include contract durations.

Therefore, it is reasonable that a cancellation of a contract as a response to a (relative) price change is delayed. Furthermore, other tariffs do not include a contract duration or monthly subscription fee. Thus, the current price does also influence the current level of the mobile subscription rate due to the possibility of a quick cancellation or the conclusion of a second contract. Additionally, in all periods new customers can decide, based on the current price, to conclude new mobile contracts. In aggregated data, this does usually not play an important role as subscriber levels are aggregated by country. Both prices are supposed to have a negative impact on the mobile subscription rate, meaning that an increase in the own price leads to a decrease in the number of subscribers.

In order to find substitutional effects, the fixed-line price must have a positive effect on mob_{sub}. We employ the first lag of the fixed-line price, as we assume that fixed to mobile substitution on access level can be seen as a quite slow process. One possible explanation is that fixed-lines are usually used by households, and not by individuals. Therefore, the cancellation of the fixed-line access affects all family members. Hence, the reaction to a change in price will be delayed and will then not depend on the current price, but on the former fixed-line price.

The term $x_{it,k}$ includes all additional explanatory variables such as GDP, the population size, fixed-line Internet subscribers, percentage of urban population and prepaid users. GDP and $perc_{urban}$ are included due to the fact that in developed countries telecommunication technologies are likely used more often. Additionally, the quality of the fixed line network is assumed to be much better than in low developed countries. $Internet_{sub}$ measures the importance of the fixed line technology as fixed lines have the premium of high speed Internet. Furthermore, we also included $Internet_{sub}$ to control for IP telephony. $perc_{prepaid}$ is included as a larger number of prepaid customers probably lead to a larger mobile subscription level as prepaid contract do not include regular payments. ϵ_{it} is an error term and α and the βs are parameters to be estimated.

Checking for reverse substitution effects, i.e. from mobile towards fixed line networks, we re-estimate equation (2.1) by replacing the variable mob_{sub} with fix_{sub}. Although it is possible to find substitutability towards fixed technologies, we have to keep in mind that fixed-line phones can never be a full substitute for mobile devices due to its lack of mobility. In addition to that, the cancellation of a fixed-line contract is more complex since a fixed-line access is related to a whole household and usually not to an individual. Furthermore, households will not have more than one contract as this might be the case for mobile phones. Thus, we assume that fixed-line subscription does not depend on the current own price, but on the former fixed-line price. Again, to find substitution effects from mobile towards fixed-line networks, we need to find positive cross-price elasticities. We include the current mobile price as well as the lagged mobile price. Since we argue that people will only have one fixed-line contract, a new fixed-line contract will only be concluded by former mobile-only consumers.

$$fix_{sub_{it}} = \beta_1 fix_{sub_{it-1}} + \beta_2 p_{fix_{it-1}} + \beta_3 p_{mob_{it}} + \beta_4 p_{mob_{it-1}} + \sum \beta_k x_{itk} + \alpha_i + \epsilon_{it} \tag{2.2}$$

We expect $fix_{sub_{it-1}}$ to have a positive influence on current fixed line subscription rates for the simple reason that if there were more fixed line subscribers yesterday, there will be more subscribers today. Again, this is the persistence argument which also holds for the mobile subscribers series.

We suppose that the own-price elasticity is negative. In order to find substitutional effects, the mobile prices must have a positive effect on fix_{sub}. The term $x_{it,k}$ again includes all additional explanatory variables such as GDP, the population size, the number of fixed-line Internet subscribers, the percentages of the urban population and prepaid users. ϵ_{it} is an error term and α and the βs are parameters to be estimated.

Controlling for unobserved heterogeneity and endogeneity problems due to our dynamic setup, we apply the one-step System GMM estimator suggested by Arellano and Bover (1995), Blundell and Bond (1998), and Blundell, Bond and Windmeijer (1998), which is an extension of the estimator developed by Arellano and Bond (1991). In addition to the inclusion of lagged levels and differences of dependent variables as instruments for our lagged dependent and endogenous variables, we also incorporate further instruments to solve possible endogeneity problems. As we estimate demand functions, we have to solve possible endogeneity problems due to simultaneity which may arise due to the fact that quantities and prices influence each other simultaneously. We restrict the maximal number of lags to two. It is well known from the econometrics literature that Arellano-Bond type estimators perform relatively poor in small samples. Following Blundell et al. (1998), including additional moment conditions helps significantly to overcome the finite sample bias. Additionally, we apply the system GMM estimator which does not only improve the precision, but also reduces the finite sample bias problem. The good performance of system GMM estimators in finite sample settings has also been confirmed by recent simulation studies (Soto, 2009).

Preventing spurious regressions, we apply panel unit root tests for all variables in our dataset. The results of the test statistics can be found in table 2.13 in the appendix. We find that three of our independent variables, gdp_{pc}, $perc_{urban}$ and mtr, are integrated of second order or higher.[5] However, our GMM estimator applies a first differences transformation, ensuring that non-stationary variables can not cause spurious regression problems because our left-hand side variables are stationary after applying first-differences. Furthermore, cointegration relationships cannot be present in our dataset, because we do not have identical orders of integration on the left-hand side and the right-hand side of our equations. In fact, cointegration would not cause spurious correlation, but one would have to estimate error correction models to be able to disentangle short- and long-run effects (Engle/Granger, 1987).

Some additional remarks should be presented due to the estimation of our system of equations. We apply single equation techniques to estimate the fixed- and mobile-equations, because generally single equation estimators as 2SLS are more robust than simultaneous multiple equation estimators as for example 3SLS. The main advantage of system estimators is their improved efficiency compared to single equation estimators. However, there is an important requirement for such efficiency gains: all equations in the system have to be specified correctly. Single equations methods as 2SLS estimate one equation of the system consistent and asymptotically normal, when the equation is specified correctly and the instruments work quite well. The most important weakness of estimators as 3SLS and simultaneous GMM estimators is their property that if one equation in a system is misspecified, all parameter estimates of the system are inconsistent[6]. As a result, misspecifications in one equation spill over to the estimates of the other equations

[5] For further information see Hamilton (1994).

[6] For further discussion see Wooldridge (2010).

of the system. The following section provides our main estimation results as well as their interpretation.

2.3.3 Empirical Results

In order to solve possible endogeneity problems, we instrument the fixed and mobile average call prices with termination rates. We include the current mobile termination rates as well as their first lag. Table 2.4 shows the correlation of the fixed and mobile call prices and mobile termination rates. Termination rates are an

Table 2.4: Correlation between fixed and mobile prices and mobile termination rates

	$p_{mob_{it}}$	$p_{mob_{it-1}}$	$p_{fix_{it-1}}$
mtr_{it}	0.6098*	0.5955*	0.6109*
mtr_{it-1}	0.5748*	0.5867*	0.5883*

* significant on 5% level or higher

important (variable) cost factor for the mobile operators which occur particularly for off-net calls. The national regulatory authorities in each country determine the termination charges which can therefore be considered as exogenous. This assumption can be criticized as the decision of the regulator is affected by other factors such as changes in volumes. However, this effect appears more likely in the long-run, but can be assumed to be exogenous in the short-run due to the structure of our regression model. Nevertheless, termination rates are the only cost shifter which directly influences the variable costs and can be observed by an econometrician (Briglauer et al., 2011, p. 13). By applying Sargan tests, we test for the exogeneity of our instruments and we cannot reject the null hypothesis stating exogeneity of our instruments (Wooldridge, 2010). Table 2.5 illustrates our results.[7] We perform several robustness checks. We also estimate our model

[7]Due to multicollinearity problems, we cannot include all 3 mobile call prices into our regression. Instead, we use the mobile call price for low users because of its larger variation. However, we also estimate our model including the medium or high usage price. The results are reported in table 2.11 in the appendix.

by replacing the linear time trend and gdp_{pc} with time dummies and gdp. Additionally, we follow Madden and Coble-Neal (2004) and also incorporate network effects in our equations. The results do not change significantly and can be found in table 2.12 in the appendix.

For the regression on mobile subscriptions (equation (2.1)), we identify statistically significant effects at a 5% or higher significance level from the first lag of mobile subscription, the current mobile price, the lagged fixed-line price and population. All significant variables have the expected signs. The lag of mobile subscription has a large positive effect on the current mobile subscription which is significant at a 1% significance level. The own-price elasticity is negative as expected. The beta coefficient of the lagged fixed-line price is +0.19 which indicates that a 1% increase in the lagged fixed-line price would lead to a 0.19% increase in the current mobile subscription rate. One should note that this finding is an indicator of fixed-mobile substitution on the subscriber stage. As a result, we find a causal link from fixed-line prices to mobile subscriptions, because increasing fixed-line prices tend to increase mobile subscriptions. Obviously, we do not know whether customers really terminate their fixed-line contracts, but the fostering effect of fixed-line prices on mobile subscriptions is a strong indicator for this kind of substitution pattern. This represents the standard way demand estimations are interpreted in most applied economic research (see Holden et al., 1990, p. 112 et seqq.; Davis/Garces, 2010, p. 436 et seqq.). Substitutes are defined as goods where an increase in good a's price increases the demand for good b (see Pindyck/Rubinfeld, 2012), which means that b is a substitute for a. We observe this situation exactly for the price of fixed-line calls and mobile phone subscriptions. The deviation in our empirical analysis is that substitutability is assymmetric. Mobile phones cannot be fully substituted by fixed-line phones due to the lack of mobility. Furthermore, the magnitude of the cross-price elasticity found is in range with previous empirical findings. However, comparisons should be treated with caution because other research work uses different datasets and estimation methods. In addition, population has a significantly positive effect on mobile subscription.

For the regression on fixed-line subscriptions (equation (2.2)), we only find significant effects for the first lag of fixed-line subscription and its own price, both

Table 2.5: Estimation results for EQ (2.1) and EQ (2.2)

Variable	Mob_{sub}	Fix_{sub}
$mob_{sub_{it-1}}$	0.8952***	
	(0.0454)	
$fix_{sub_{it-1}}$		0.9598***
		(0.0243)
$p_{fix_{it-1}}$	0.1877**	-0.1225**
	(0.0810)	(0.0511)
$p_{mob_{it}}$	-0.1573**	-0.0003
	(0.0700)	(0.030)
$p_{mob_{it-1}}$	0.0695	0.0056
	(0.0430)	(0.0302)
$gdp_{pc_{it}}$	0.0078	0.0378*
	(0.0580)	(0.0229)
pop_{it}	1.045e-0.8**	3.389e-0.9
	(4.26e-0.9)	(2.70e-0.9)
$internet_{sub_{it}}$	-1.21e-0.8	2.44-0.9
	(8.55e-0.9)	(4.20-0.9)
$perc_{prepaid_{it}}$	-0.0637	0.0446
	(0.1256)	(0.0645)
$perc_{urban_{it}}$	-0.0350	-0.1343
	(0.2962)	(0.1541)
$time$	-0.0140	-0.0017
	(0.0096)	(0.0038)
$cons$	1.7730*	0.1112
	(1.0683)	(0.4427)
$chi2$	1438.1796	9486.3845
N	134	134

$*$,$**$,$***$ indicate statistically significant on the 10%, 5%, and 1% level
Heteroscedasticity robust standard errors in parenthesis
Endogenous variables: $mob_{sub_{it-1}}$, $fix_{sub_{it-1}}$, $p_{fix_{it-1}}$, $p_{mob_{it}}$, $p_{mob_{it-1}}$
Instrumental variables: mtr_{it}, mtr_{it-1}

on a 5% significance level or higher. In addition, GDP per capita is significant on a 10% level. Again, all significant variables have the expected signs.
Overall, our findings provide evidence for one-way-substitution. One can substitute a fixed-line phone by a mobile phone, but mobile phones are only partially substitutable by fixed-line phones because of the lack of mobility. One should note that the result of one-way-substitution is in line with the earlier findings in Heimeshoff (2008). However, in many countries in our dataset fixed telephone markets are highly saturated, which implies that a positive effect of increasing mobile prices on fixed-line subscriptions should not be expected. One reason is that most households only have one fixed-line phone and another is that mobile phones, as we discussed earlier, can only be substituted partially by fixed-line phones. Therefore, the lack of finding a statistically significant relationship between fixed-line subscriptions and mobile call prices can be explained.
In addition, we run different specification tests. First of all, we apply the Arellano-Bond test for zero autocorrelation in first-differenced errors. We find first order autocorrelation[8], but no second order autocorrelation in both regressions (with p-values of 0.71 and 0.27). Furthermore, the Sargan test indicates the validity of our specifications (Table 2.6).

Table 2.6: Sargan test of overidentifying restrictions

	EQ (2.1)	EQ (2.2)
$chi2(32)$	36.2051	41.5229
$Prob > chi2$	0.2787	0.2077

H0: overidentifying restrictions are valid

Our empirical findings suggest a fixed-line own-price elasticity of -0.12 and a mobile own-price elasticity of -0.16, which indicates that the mobile demand is more elastic than the demand for fixed-line subscription. The cross-price elasticity of the mobile price is insignificant, whereas the cross-price elasticity of the fixed-line price is +0.19. Thus, our study confirms modest one-way substitution

[8] As the first difference of independently and identically distributed idiosyncratic errors will be autocorrelated, rejecting the null hypothesis of no serial correlation at order one in the first-differenced errors does not imply that the model is misspecified. Rejecting the null hypothesis at higher orders implies that the moment conditions are not valid.

from fixed to mobile services on the access level. However, with the evolution of new mobile services and especially high-speed mobile Internet, the magnitude of fixed-mobile substitution will likely increase. The following section concludes and provides some discussion of policy implications.

2.4 Conclusion and Policy Implications

This chapter has analyzed fixed-mobile substitution on the basis of the relationship between fixed and mobile subscriptions in the European Union between 2003 and 2009. The main problem in studying fixed-mobile substitution and mobile phone usage in all European Union countries is the unavailability of traffic data disaggregated for fixed-line telecommunications services. To avoid these difficulties we have used the numbers of fixed and mobile subscriptions in each country and have estimated effects of price changes of the respectively other product on fixed and mobile penetration rates. In the next chapter, we will focus on fixed-mobile substitution on traffic level using data of at least 16 European countries. Studying all 27 EU countries from 2003 to 2009 on annual basis, we find evidence for substitutability of fixed and mobile services, but have some problems of endogeneity in our econometric model which are solved by instrumenting prices with termination rates. However, one has to note that we only find one-way-substitution, because cellular phones usually cannot be substituted completely by fixed-line devices.

With regard to regulation of telecommunications markets fixed-mobile substitutability has a wide ranging impact. Most mobile telecommunications markets in Europe are not very heavily regulated, an observation which holds for most parts of the world (Nuechterlein/Weiser, 2005, p. 261). Exceptions are issues like spectrum allocation, mobile number portability, mobile termination rates, and international roaming. In contrast, fixed telecommunications markets are subject to considerable regulatory obligations[9]. Due to these regulatory differences, incentives to invest in the mobile sector are fostered leading likely to higher quality and better prices. These developments might further increase the substitutability towards mobile technologies. These different approaches have been quite reason-

[9]See Laffont/Tirole (2000) for further details.

able when mobile communications services were very expensive and only available for a small number of customers. Today, decreasing prices and the growing substitution between fixed and mobile services raise the question whether two different regulatory regimes for fixed and mobile markets are still appropriate. Consider the verification of significant market power: If fixed and mobile services are substitutes, it is not sufficient that a telecommunications company has significant market power (or a main share of the market) in the market for fixed-line services because customers use mobile services as substitutes to the company's fixed-line services and are not constrained to fixed-line telephony. As a result, it would be difficult to appropriate rents as a consequence of significant market power in fixed or mobile markets only. If the evolution of usage patterns suggests that mobile telecommunications services constrain fixed-line companies' market power, regulatory obligations on fixed telephony markets have to be reconsidered (Rodini et al., 2003, p. 475). In conjunction with these developments the suitability of the definition of separate fixed and mobile markets in the current European regulatory framework may need to be reconsidered for future telecommunications regulation.

There are additional aspects besides the convergence of fixed and mobile networks, which fundamentally affect the development of telecommunications markets . One of these aspects is the market success of voice telephony over Internet protocol (VoIP) (Majumdar et al., 2005). If VoIP becomes the industry standard for voice telephony, services of classical fixed and mobile networks could be substituted by VoIP and different forms of networks will converge. An interesting subject for future research is the impact of increasing availability as well as quality and security of VoIP on the number of subscribers and usage of traditional fixed and mobile services. In Germany as well as in other European countries the availability of appropriate data is always problematic. In transition or developing countries the situation is very different as a result of the poor fixed-line infrastructure and the corresponding low growth rates. Growth rates of mobile communications are much higher than growth rates of fixed networks in these countries. As a consequence, we will observe other forms of network convergence than in developed countries. The future development and regulation of telecommunications markets will remain an important field of research, particularly because of technological change which will be a key aspect for fixed-mobile substitution and the meaning of telecommunications for economic growth and development (Munnell, 1992; Norton, 1992; Röller/Waverman, 2001; Czernich et al., 2011).

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Appendix

Table 2.7: Member States of the European Union

Country	Period	Country	Period
Austria	2003-2009	Latvia	2004-2009
Belgium	2003-2009	Lithuania	2004-2009
Bulgaria	2007-2009	Luxembourg	2003-2009
Cyprus	2004-2009	Malta	2004-2009
Czech Republic	2004-2009	Netherlands	2003-2009
Denmark	2003-2009	Poland	2004-2009
Estonia	2004-2009	Portugal	2003-2009
Finland	2003-2009	Romania	2007-2009
France	2003-2009	Slovakia	2004-2009
Germany	2003-2009	Slovenia	2004-2009
Greece	2003-2009	Spain	2003-2009
Hungary	2004-2009	Sweden	2003-2009
Ireland	2003-2009	UK	2003-2009
Italy	2003-2009		

Methodology of the Teligen/OECD Price Baskets

Combining a certain usage profile with relevant tariffs, each Teligen/OECD price basket describes a theoretical user based on research supported by operators in a large number of OECD countries to enable international comparisons. The following tables 2.8 and 2.9 summarize the main properties of the baskets (2002 version).

Table 2.8: Main Properties of the Residential Basket (Version 2000), calls per year

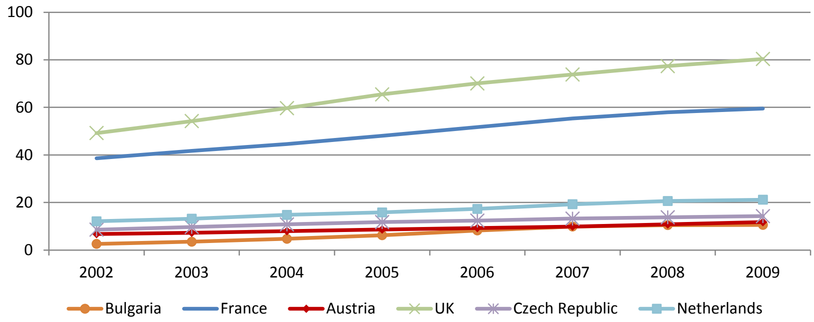
	National calls	International calls	Calls to mobile
Residential basket	1200	72	120

Table 2.9: Main Properties of the Mobile Baskets (Version 2002), calls per year

	Outgoing calls	SMS	To Mobile	To Fix
Low	300	360	58%	42%
Medium	900	420	64%	36%
High	1800	504	60%	40%

Each basket also assumes a unique definition of time of day and call duration and contains components for fixed fees and usage in terms of voice and messages. Taking SMS prices from the OECD Communication Outlook 2009, we calculate costs of text messages. For the remaining six countries which do not belong to the OECD, we use average SMS prices of the included OECD countries. In order to calculate call prices, we subtract the calculated SMS costs from the total costs of each basket. Then, our baskets only contain costs related to voice calls and subscription fee. Therefore, we divide the annual costs of each specific basket by the assumed calls per year and use these average prices in our analysis. In order to derive the fixed-line price, we just divide the total costs of the residential basket by the amount of assumed calls.

Figure 2.3: Development of mobile subscription rates (in millions) in selected Western and Eastern European countries



Source: ITU, 2010

Table 2.10: Pairwise Correlation between variables

	p_{fix}	p_{mob}	gdp	gdp_{pc}	$time$
p_{fix}	1.0000				
p_{mob}	0.3374*	1.0000			
gdp	-0.1521*	0.1343	1.0000		
gdp_{pc}	-0.4154*	-0.2078*	0.1971*	1.0000	
$time$	-0.0113	-0.3454*	0.1259	0.2073*	1.0000
pop	-0.0614	0.3360*	0.7250*	0.0726	0.0055
$internet_{sub}$	-0.1664*	0.2413*	0.6664*	0.2052*	0.0758
$perc_{prepaid}$	0.2987*	0.4135*	-0.0200	-0.1332	-0.0532
$perc_{urban}$	-0.3086*	-0.0007	0.2881*	0.4920*	0.0246
	pop	$internet_{sub}$	$perc_{prepaid}$	$perc_{urban}$	
pop	1.0000				
$internet_{sub}$	0.9099*	1.0000			
$perc_{prepaid}$	0.0690	0.0166	1.0000		
$perc_{urban}$	0.1392	0.2411*	0.0282	1.0000	

* significant on 5% level or higher

Table 2.11: Empirical Results for EQ(1) with different mobile prices

Variable	Mob_{sub}		
p_{mob}	Low Usage	Medium usage	High usage
$mob_{sub_{it-1}}$	0.8952***	0.9138***	0.9468***
	(0.0454)	(0.0513)	(0.0424)
$p_{fix_{it-1}}$	0.1877**	0.1736**	0.1590**
	(0.0810)	(0.0804)	(0.0811)
$p_{mob_{it}}$	-0.1573**	-0.0337	-0.0378
	(0.0700)	(0.0550)	(0.0448)
$p_{mob_{it-1}}$	0.0695	0.0497	0.0712
	(0.0430)	(0.0575)	(0.0455)
$gdp_{pc_{it}}$	0.0078	0.0072	0.0113
	(0.0580)	(0.0530)	(0.0511)
pop_{it}	1.045e-0.8**	8.347e-09*	6.588E-09
	(4.26e-0.9)	(0.0000)	(0.0000)
$internet_{sub_{it}}$	-1.21e-0.8	-1.33E-08	-1.21E-08
	(8.55e-0.9)	(0.0000)	(0.0000)
$perc_{prepaid_{it}}$	-0.0637	-0.0671	-0.0775
	(0.1256)	(0.1723)	(0.1648)
$perc_{urban_{it}}$	-0.0350	0.1335	0.1823
	(0.2962)	(0.2646)	(0.2027)
$time$	-0.0140	-0.0037	-0.0060
	(0.0096)	(0.0122)	(0.0104)
$cons$	1.7730*	1.4364	0.8825
	(1.0683)	(1.0711)	(0.8087)
$chi2$	1438.1796	2351.3000	4594.1300
N	134	134	134

$*$,$**$,$***$ indicate statistically significant on the 10%, 5%, and 1% level
Heteroscedasticity robust standard errors in parenthesis
Endogenous variables: $mob_{sub_{it-1}}$, $p_{fix_{it-1}}$, $p_{mob_{it}}$, $p_{mob_{it-1}}$
Instrumental variables: mtr_{it}, mtr_{it-1}

Table 2.12: Empirical Results for specification (1) including time dummies and GDP and specification (2) including network effects in addition

	Specification (1)		Specification (2)	
Variable	Mob_{sub}	Fix_{sub}	Mob_{sub}	Fix_{sub}
$mob_{sub_{it-1}}$	0.8977***		0.8583***	
	(0.0424)		(0.0717)	
$fix_{sub_{it-1}}$		0.9481***		1.0799***
		(0.0268)		(0.0479)
$p_{fix_{it-1}}$	0.2167**	-0.1453***	0.1949***	-0.0780
	(0.0849)	(0.0581)	(0.0682)	(0.0490)
$p_{mob_{it}}$	-0.1545*	-0.0080	-0.0802*	-0.0036
	(0.0867)	(0.0314)	(0.0448)	(0.0319)
$p_{mob_{it-1}}$	0.0489	0.0167	0.0014	-0.0056
	(0.0503)	(0.0305)	(0.0406)	(0.0260)
gdp_{it}	0.0322***	0.0023	0.0243	0.0054
	(0.0124)	(0.0060)	(0.0112)	(0.0064)
pop_{it}	6.424e-0.9*	3.74e-0.9	4.59e-0.9	1.15e-0.9
	(3.63e-0.9)	(2.55e-0.9)	(3.26e-0.9)	(2.30e-0.9)
$internet_{sub_{it}}$	-2.82e-0.9	-1.00e-0.9	-3.03e-0.9	1.51e-0.9
	(5.12e-0.9)	(3.51e-0.9)	(3.69-0.9)	(3.30e-0.9)
$perc_{prepaid_{it}}$	-0.0711	0.0173	-0.0656	0.0693
	(0.1012)	(0.0680)	(0.1282)	(0.0838)
$perc_{urban_{it}}$	-0.2204	-0.1075	-0.2535	-0.1966
	(0.2676)	(0.1417)	(0.2228)	(0.1538)
Network effects				
$mob_{sub_{it}}$				-0.1098**
				(0.0447)
$fix_{sub_{it}}$			0.0646	
			(0.0614)	
$d2004 - d2009$	yes	yes	yes	yes
$cons$	1.1408*	0.5554	0.9785	0.3716
	(0.6288)	(0.4525)	(0.6347)	(0.4949)
$chi2$	3535.0496	14685.7230	6953.1003	22201.2690
N	134	134	134	134

$*$,$**$,$***$ indicate statistically significant on the 10%, 5%, and 1% level
Heteroscedasticity robust standard errors in parenthesis
Endogenous variables: $mob_{sub_{it}}$, $mob_{sub_{it-1}}$, $fix_{sub_{it}}$, $fix_{sub_{it-1}}$, $p_{fix_{it-1}}$, $p_{mob_{it}}$, $p_{mob_{it-1}}$
Instrumental variables: mtr_{it}, mtr_{it-1}

Table 2.13: Maddala-Wu Unit Root Tests

	Levels	First differences
mob_{sub}		
$chi2$	40.9792	77.4336
$Prob > chi2$	0.9041	0.0200
fix_{sub}		
$chi2$	47.9354	189.9100
$Prob > chi2$	0.7061	0.0000
p_{fix}		
$Prob > chi2$	163.6148	132.1633
$Prob > chi2$	0.0000	0.0000
p_{mob}		
$chi2$	30.9646	93.9217
$Prob > chi2$	0.9950	0.0002
gdp		
$chi2$	5.3792	16.1754
$Prob > chi2$	1.0000	1.0000
gdp_{pc}		
$chi2$	3.1671	1.3283
$Prob > chi2$	1.0000	1.0000
pop		
$chi2$	170.4307	96.9878
$Prob > chi2$	0.0000	0.0003
$internet_{sub}$		
$chi2$	115.0975	149.4541
$Prob > chi2$	0.0000	0.0000
$perc_{prepaid}$		
$chi2$	63.2590	71.1455
$Prob > chi2$	0.1820	0.0589
$perc_{urban}$		
$chi2$	28.4259	5.1719
$Prob > chi2$	0.9984	1.0000
mtr		
$chi2$	24.4345	43.0712
$Prob > chi2$	0.9998	0.8570

Ho: unit root

Chapter 3

What is the Magnitude of Fixed-Mobile Call Substitution? Empirical Evidence from 16 European Countries*

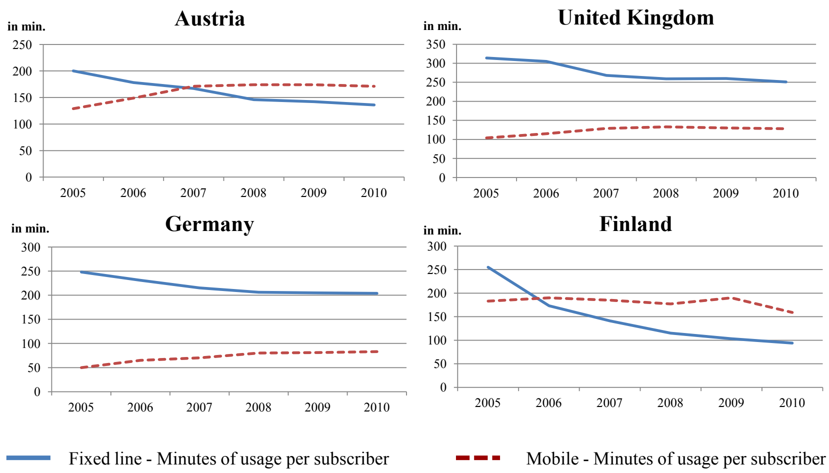
3.1 Introduction

After the implementation of GSM digital technology at the beginning of the 1990s, mobile devices became mass products, prices dropped and penetration rates dramatically increased (Hausman, 2002; Gruber, 2005). As well as the fact that the number of mobile subscribers has been larger than the number of fixed-line subscriptions since the early 2000s, we observe that fixed and mobile voice traffic volumes are converging. Whereas mobile call volumes are rising, fixed-line voice traffic volumes have continuously declined over the past decade. Figure 3.1 exemplifies the development of the average monthly fixed and mobile voice traffic per subscriber for four different European countries from 2005 to 2010. It is obvious that the progress of convergence varies between countries. For instance, in Austria and Finland mobile voice traffic has already exceeded the fixed-line traffic several years ago, and continues to do so. In other countries, such as Germany and

*The research of this chapter is part of a joint project with Ulrich Heimeshoff.

the UK, however, fixed-line phones are still used more often to place calls than mobile devices.

Figure 3.1: Development of the average monthly fixed and mobile voice traffic volumes per subscriber between 2005 and 2010 (in minutes)



Source: Analysys Mason, 2011a

Fixed and mobile telecommunications markets are monitored by national regulatory authorities (Laffont/Tirole, 2000), but the degree of regulation is quite different. On the one hand, fixed markets are regulated quite heavily. On the other hand, mobile markets are regulated less restrictively, as they were more competitive from their inception (Haucap, 2003). However, recent observations lead to the question whether the asymmetric regulation of fixed and mobile markets is still appropriate.
The number of econometric studies which analyze the substitutional relationship between fixed and mobile networks is limited and their results are quite ambiguous. The main reason tends to be that most of the studies use quite old data, i.e. up to 2003. In contrast, studies using more recent data, including Briglauer et al. (2011), Grzybowski (2011), Barth/Heimeshoff (2011) and Ward/Zheng (2012), unanimously conclude that the two services are substitutes, at least in developed countries. These findings substantiate that fixed-mobile substitution already pre-

vails. Consequently, the research focus has shifted from the question of whether the two technologies are substitutes or not, to the question of to what extent fixed and mobile networks are substitutable, and whether the magnitude found is strong enough to justify regulatory adjustments.

Few studies exist that focus specifically around the traffic level, and all find different degrees of substitutability. Additionally, there is, to the best of our knowledge, no econometric paper analyzing fixed-mobile call substition (FMCS) in a multiple-countries setting. Therefore, the present results should be interpreted with caution as these are likely biased due to problems with unobserved heterogeneity.

The purpose of this chapter is to help to close this research gap. We address fixed-mobile call substitution within 16 mainly Western European countries. Using quarterly data from 2004 to mid-2010, the chapter analyzes to what extent fixed and mobile phone calls are substitutes. Our chapter is structured as follows: Section 3.2 provides an overview of the empirical literature related to fixed-mobile substitution; in section 3.3, the dataset and its descriptive statistics will be explained; section 3.4 introduces our model specification and describes our estimation approach; and section 3.5 explains our main results. Section 3.6 concludes.

3.2 Literature Review

Fixed-mobile substitution (FMS) can be analyzed on different levels: subscribers and traffic (ITU, 2010). Hence, empirical research on penetration models, as well as studies estimating access or calling demand, are relevant for the analysis of FMS (Vogelsang, 2010, p. 8). To analyze the substitutability between products, usually own- and cross-price elasticities are estimated (Taylor, 1994). The following two subsections separately discuss the existing literature on the access and traffic level.

3.2.1 Access Level

The results concerning FMS on access level (FMAS) show a rather mixed picture. While some studies find fixed and mobile services to be complements at the subscription level, others find substitutability.

In their study using data from 1991 to 1998 for 8 South Korean provinces, Sung and Lee (2002) find that a 1% increase in the number of mobile phones results in a 0.1-0.2% reduction of fixed-line connections. Therefore, they conclude that the two technologies are substitutes on South Korean telecommunications markets.

In contrast, Gruber and Verboven (2001) deduce from their study on 140 countries from 1981 to 1995 that the diffusion of mobile phones tends to be larger in countries with higher fixed network penetration. Thus, they argue that fixed and mobile networks are complements.

Analyzing time series data on fixed and mobile access in Portugal from 1981 until 1999, Barros and Cadima (2000) identify a negative effect of mobile phone diffusion on fixed-line penetration rates, but not vice versa. Their results indicate asymmetric fixed-to-mobile access substitution.

Rodini, Ward, and Woroch (2003) make use of US household survey data for the time period 1999 to 2001. They investigate the substitutability between fixed and mobile access in the USA modeling the consumers wireless and second fixed-line subscription decision and applying logit regressions. By estimating own- and cross-price elasticities, they find moderate substitution effects.

Employing annual data on 23 African countries for the time period 1985 to 1997, Hamilton (2003) shows that fixed and mobile phones in many African countries are still not substitutes. Hamilton argues that the usage of mobile phones does not reduce the demand for fixed-line services, but is primarily an improvement in social status.

Based on data from 56 countries between 1995 and 2000, Madden and Coble-Neal (2004) examine FMS in a dynamic demand model and assess significant substitution effects between mobile and fixed-line subscription rates.

Using South African survey data from 1998-2001, Hodge (2005) studies how differences in tariff structures between fixed and mobile services have accounted for the popularity of the cellular technology. Hodge finds that in low income households, mobile phones are perceived as substitutes, while in high income households the two services are treated as complements.

Vagliasindi, Güney, and Taubman (2006) observe substitutional relationships between fixed and mobile services for Eastern European countries in 2002. However, in contrast to other studies, the authors use a cross section instead of panel data.

Garbacz and Thompson (2007) analyze FMS in 53 less developed countries from 1996 to 2003, finding asymmetric substitutional effects. While fixed connections tend to be substitutes in the mobile market, mobile phones might be complements in the fixed-line market.

Using cross sectional survey data for 2003, Narayana (2010) includes subscription prices as well as usage prices as explanatory variables in his regression, and finds that both prices are correlated and that the usage price has, compared to the subscription price, a much larger and more significant effect on the mobile and fixed-line subscription. Moreover, Narayana finds much stronger substitutional effects in both directions than other studies.

Heimeshoff (2008) studies FMS on the access level and estimates cross-price elasticities in 30 OECD countries between 1990 and 2003 by applying 2SLS IV estimation. He finds one-way substitution, meaning that mobile networks can be a substitute to fixed-line services, but not vice versa.

Ward and Woroch (2010) estimate cross-price elasticities between fixed and mobile subscription by making use of the same US household survey as Rodini et al. (2003). In addition, they incorporate data from US low-income subsidy programs (Lifeline Assistance) which cause large changes in the fixed-line prices. Although they use the identical survey data, the elasticities found are much larger than those for second fixed-lines in Rodini et al. (2003).

Based on data from the European Union for 2006 to 2009, Gryzbowski (2011) structurally estimates the demand for mobile access conditional on having fixed-line access and the demand for fixed-line conditional on having mobile access. He concludes that mobile and fixed-line networks are perceived as substitutes in Western European countries and as complements in Central and Eastern Europe.

Using South Korean survey data for 2007 and a hierarchical Bayes model for discrete choice data, Rhee/Park (2011) find some evidence for the separation of the fixed-line and mobile telephony markets in South Korea. However, the authors predict that the two markets will converge in the near future as the mobile price premium continues to decrease.

Caves (2011) utilizes US state-level panel data from 2001 to 2007 and estimates single equation models as well as simultaneous equation models for fixed and mobile demand. The author studies wireless and wireline access demand and finds that a one percent decrease in wireless prices results in a 1.2-1.3% decrease in the demand for fixed line services.

In a previous paper (Barth/Heimeshoff (2011)), we have estimated the effect of several variables, particularly prices, on the stocks of fixed and mobile subscription rates. Applying dynamic panel approaches and using data of the EU27 from 2003 to 2009, our results indicate modest substitution effects towards mobile telecommunication networks.

Ward and Zheng (2012) analyze fixed-mobile access substitution for 31 Chinese provinces from 1998 to 2007. Using Arellano-Bond type linear dynamic panel models, the authors estimate short- and long-run elasticities of fixed and mobile prices on fixed and mobile subscriptions, respectively and find cross-price elasticities between 0.20 and 0.28 in the short-run and 0.39 and 0.56 in the long-run. In comparison to other empirical studies Ward and Zheng (2012) find rather strong substitutional effects. Endogeneity problems are dealt with using further lags as well as measures like the average Herfindahl index and the fraction of state ownership in fixed and mobile telecommunications for neighboring nearest provinces.

Using quarterly Spanish household survey data for 2004-2009 and logistic regression techniques, Suarez and Garcia-Marinoso (2013) quantify the percentage of households that engage in fixed to mobile access substitution in Spain and the drivers of FMAS. They find the substitutability (0.02% to 0.79% per quarter) to be rather small. The main drivers for FMAS are the availability of Internet and mobile services previous to the substitution decision, socio-demographic characteristics of households, such as age, and the degree and types of expenditure on fixed services.

Next to the papers focusing on the substitutability of voice services, Srinuan et al. (2012) examine Swedish survey data for 2009 and investigate whether fixed and mobile broadband services are complements or substitutes. They find that fixed and mobile broadband technologies are substitutes in most geographical parts of Sweden. Applying logit techniques and including prices for different Internet technologies (DSL, cable, LAN/Fibre and mobile Internet), the authors find that DSL and mobile broadband are more sensitive to price changes than cable and

LAN/Fibre, whereas the degree of substitutability varies from area to area.
To sum up, studies merely exist for South Korea, Portugal, the USA, and some African and Eastern European countries. In addition, recent papers address FMS in India, China, Spain, the OECD and the European Union. Furthermore, the results are not as clear as expected. A possible reason might be that the estimation of cross-price elasticities is typically less robust than own-price effects (Bonfrer et al., 2006).
However, the results give some evidence that fixed and mobile services are already perceived to be substitutes in developed countries, but not (yet) in low-income countries. This finding is not surprising, as in many African and other less developed countries an extensive fixed-line infrastructure is missing. Thus, mobile phones are often the only possibility of having access to telecommunications services.
Another reason for the different findings could be that the majority of empirical studies use quite old data, up to 2003 at latest. It is likely that the substitution effects of fixed and mobile networks are much stronger nowadays, e.g. due to further price reductions in mobile markets. Our previous work aims to help to fill this research gap by using data up to 2009. However, we only find moderate, but highly significant one-way access substitution in favor of mobile networks, but we expect the substitution effects to be much larger on the traffic level. The next subsection will discuss the existing research related to the traffic level.

3.2.2 Traffic Level

The findings on the traffic level are much clearer. All studies focus on single developed countries and find substitutional effects on the traffic level.
Horvath and Maldoom (2002) study survey data of over 7000 British telephone users (repeated cross section in three waves: 1999, 2000, 2001) in a simultaneous equations model, and additionally estimate some probit regressions. They find that using mobile phones significantly decreases fixed-line usage. Their findings support the conclusion that fixed and mobile phones are substitutes in British telecommunications markets.
By analyzing monthly traffic and revenue data from 1997 to 2002 for South Ko-

rea, Yoon and Song (2003) show that fixed and mobile calls are substitutes and fixed-mobile convergence can be observed in South Korea. Sung (2003) reports that mobile calls are substitutes for fixed-line toll calls by using Korean regional panel data for 1993 to 1997. Using traffic data from 1996 to 2002 for South Korean telecommunications markets, Ahn, Lee, and Kim (2004) concur with these results.

Ward and Woroch (2004) again make use of the US bill-harvesting data and report comparable effects, applying the Almost Ideal Demand System-Model (AIDS) (Deaton/Muellbauer, 1980). They conclude that mobile services are substitutes for fixed-line usage at the traffic level, but not at the access level. However, the effect is only of moderate strength.

Adopting least squares and 2SLS regression based again on the similar US survey data, Ingraham and Sidak (2004) analyze the effect of long-distance fixed-line call prices on mobile demand and report a small, but highly significant cross-elasticity of +0.022.

Briglauer et al. (2011) estimate short- and long-run cross-price elasticities for fixed-line domestic calling in response to mobile price changes in Austria for 2002-2007. Therefore, they use monthly data on call minutes and take average revenues per minute as price data. While they observe small and sometimes insignificant estimates for short-run elasticities, their results for long-run cross-price elasticities suggest strong substitution effects.

To conclude, there are only a few studies analyzing FMS on the traffic level. Additionally, all papers, with the exception of Briglauer et al. (2011), again use quite old data.

Overall, it can be concluded that there is, to the best of our knowledge, no empirical study on the traffic level incorporating multiple countries. Using cross-sectional data instead of panel data is disadvantageous as it is not possible to control for unobserved heterogeneity so that results are likely to be biased.

Thus, we would like to extend this strand of literature by using panel data on 16 mainly Western European countries[1] and recent data from 2004 to mid-2010 on a quarterly basis. The following sections provide an overview of the dataset and the applied econometric approach of our empirical study.

[1] The countries in our study are summarized in table 3.3 in the appendix.

3.3 Data

Our dataset consists of the following resources: data from the Telecoms Market Matrices of Analysys Mason for the outgoing national fixed-line traffic, telecommunication usage prices and the number of prepaid customers. Information on penetration rates and GDP is found in Merrill Lynch's Wireless and Wireline Matrices. In addition, data on mobile-only customers comes from the "Eurobarometer: E-Communications Household Surveys". We also incorporate data on fixed-to-mobile and fixed-to-fixed termination rates out of the "Progress Reports on the Single European Electronic Communication Market". The surveys and reports have both been provided by the Directorate-General Information Society of the EU Commission. Furthermore, we use the OECD statistics for demographic information and BEREC's MTR Snapshot for data on mobile termination rates. Table 3.1 illustrates the descriptive statistics for all variables used in our analysis.[2]
$traffic_{fix}$ describes the total amount of national outgoing fixed-line voice traffic (in million of minutes). p_{fix} and p_{mob} represent the prices of fixed and mobile network calls per minute. These prices are constructed by dividing the total voice revenues of all operators in a specific country by the total minutes of usage. $pen_{wireless}$ and $pen_{wireline}$ refer to the penetration rates of the mobile and fixed-line network in each specific country, respectively. mtr describes the mobile termination rates, ftf the fixed-to-fixed termination rates and ftm the fixed-to-mobile termination rates. The control variable gdp stands for the GDP (in bn. USD PPP). The variable $perc_{mobonly}$ depicts the percentage of households having mobile, but no fixed-line access. $perc_{prepaid}$ describes the percentage of prepaid contracts and $perc_{under40}$ the percentage of the population aged under 40. We include the age structure of the population because we assume that a younger population uses mobile devices more often to place calls compared to older generations. pop measures the population in a specific country (in million).
A higher population probably leads to more fixed line traffic volume. $trend$ is a linear time trend. The time trend can be interpreted as a continuous improvement in the service quality, an increase in the availability of services, and an enhanced network performance (Grzybowski, 2005). We also incorporate quarterly time

[2]Additionally, the definition of the variables used can be found in table 3.4 in the appendix.

Table 3.1: Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
$traffic_{fix}$	388	11191.74	12317.79	390.80	44919.00
p_{fix}	388	0.07	0.03	0.01	0.15
p_{mob}	388	0.21	0.07	0.09	0.46
$pen_{wireless}$	388	1.13	0.21	0.64	1.86
$pen_{wireline}$	388	0.38	0.11	0.19	0.64
mtr	388	0.13	0.06	0.04	0.31
ftf	352	0.01	0.01	0.00	0.02
ftm	356	0.14	0.06	0.04	0.35
gdp	388	791.25	782.52	145.75	2829.56
$perc_{mobonly}$	388	0.28	0.18	0.00	0.81
$perc_{prepaid}$	388	0.49	0.18	0.07	0.91
$perc_{under40}$	388	0.50	0.02	0.43	0.54
pop	388	28.28	25.38	5.22	82.87
$trend$	388	14.29	7.14	1	26

dummies $d_2 - d_{26}$. For our robustness check (column 3 of table 3.2), we include a linear time trend and seasonal dummies d_{Q2} to d_{Q4} into our regression. All price variables (p_{fix}, p_{mob}, mtr, ftf, ftm and gdp), the population size pop and the fixed-line traffic volume $traffic_{fix}$ are measured in logarithms in order to interpret them as elasticities. Furthermore, all price variables are measured in USD adjusted by purchasing power parities to add in international comparison.

3.4 Model Specification

Our empirical model is based on the so-called Houthakker-Taylor model, which accounts for possible path dependencies of consumption (see Houthakker/Taylor, 1970; see also Dewenter/Haucap, 2008). Following Taylor (1994)[3], we allow for inertia and assume that an individual subscriber's demand for telephone calls (q)

[3]Taylor (1994) expects the individual subscriber's demand to also depend on the price of access to a telephone network. Unfortunately, we do not have information on access prices in our dataset. However, Briglauer et al. (2011) find that access prices are not significant in their demand estimation for calls. Furthermore, they conclude that their results are robust applying three different specifications which include 1) access plus call prices 2) only call prices or 3) average prices. Hence, it is reasonable to assume that lacking access prices will not cause significant biases in our estimation.

depends on the price of a call (π), the price of a substitute (p), the number of the network subscribers (N) and the income of the consumer (μ). Additionally, the demand is driven by K - 4 other factors ($x_{k,t}$) with k $\in [5, K]$ which include the number of the subscribers in other networks, the age of the subscriber and the type of the contract.

Let q_t^* denotes the desired number of calls during period t for given prices, level of subscribers, income and other variables. Thus, we postulate:

$$q_t^* = \alpha_0 + \alpha_1\pi_t + \alpha_2 p_t + \alpha_3 N_t + \alpha_4\mu_t + \sum_{k=5}^{k=K} \alpha_k x_{k,t}. \tag{3.1}$$

Now, q_t denotes the actual number of calls made during the period. It is assumed that whenever q and q^* diverge, a proportion of θ is eliminated within each period. In particular:

$$q_t - q_{t-1} = \theta(q_t^* - q_{t-1}), \tag{3.2}$$

where: $0 < \theta \leq 1$.

After some rearrangement, we obtain:

$$q_t = \alpha_0\theta + (1-\theta)q_{t-1} + \alpha_1\theta\pi_t + \alpha_2\theta p_t + \alpha_3\theta N_t + \alpha_4\theta\mu_t + \sum_{k=5}^{k=K} \alpha_k\theta x_{k,t}. \tag{3.3}$$

From equation (3.3), we infer that the one-period effect of a marginal change in variable i (with i = 1,...,K) on q is equal to $\alpha_i\theta$. Thus, the short- and long-run derivatives of q with respect to the variable i are equal to $\alpha_i\theta$ and α_i.

Looking at the full system of subscribers, we postulate for the aggregate demand for calls:

$$Q_t - Q_{t-1} = \psi(Q_t^* - Q_{t-1}).$$

Similarly to equation (3.1), we assume:

$$Q_t^* = \alpha_0 + \alpha_1\pi_t + \alpha_2 p_t + \alpha_3 N_t + \alpha_4 Y_t + \sum_{k=5}^{k=K} \alpha_k x_{k,t},$$

where Y_t denotes the aggregated income. Consequently, we formulate:

$$Q_t = \alpha_0\psi + (1-\psi)Q_{t-1} + \alpha_1\psi\pi_t + \alpha_2\psi p_t + \alpha_3\psi N_t + \alpha_4\psi Y_t + \sum_{k=5}^{k=K}\alpha_k\psi x_{k,t}.$$

Taking the panel structure of our data into account, the following equation studies the effects of certain variables on the national outgoing fixed-line voice traffic. Again, the one-period effect of a marginal change of variable i on the national fixed-line voice traffic is equal to $\alpha_i\psi$. Thus, the short- and long-run elasticities of the variable i are equal to $\alpha_i\psi$ and α_i, respectively.

$$\begin{aligned} traffic_{fix_{it}} &= (1-\psi)traffic_{fix_{it-1}} + \alpha_1\psi p_{fix_{it}} + \alpha_2\psi p_{mob_{it}} \\ &\quad + \alpha_3\psi pen_{wireline_{it}} + \alpha_4\psi gdp_{it} + \sum_{k=5}^{k=K}\alpha_k\psi x_{k,it} + \epsilon_{it}. \end{aligned}$$

We expect $traffic_{fix_{it-1}}$ to have a positive influence on the current fixed-line voice traffic volumes for the simple reason that if the voice traffic volumes were higher in the last quarter, they will be higher today, due to consumption habits. One reason might be that many telecommunication tariffs run for one or two years and include, for instance, free calls to specific networks. This could probably influence the calling behavior of the consumers, and therefore the usage only changes partially within the contract duration. Hence, if consumers react with some time lag, long-run elasticities are expected to be higher than the estimated short-run elasticities (Dewenter/Haucap, 2008).

We assume that the fixed-line usage depends on the current fixed-line price. We expect the own price to have a negative impact on the fixed-line usage, meaning that an increase in the own price leads to a decrease in the voice traffic volumes. In order to find substitutional effects, the current mobile price $p_{mob_{it}}$ must have a positive effect on $traffic_{fix_{it}}$. This would indicate that a marginal decrease of the mobile price would lead to declining fixed-line traffic volumes. The network effects measured by $pen_{wireline_{it}}$ and the GDP are assumed to have a positive influence on the current fixed-line traffic volumes.

The term $x_{k,it}$ includes all additional explanatory variables such as the wireless penetration rate and the population size. Additionally, the percentage of the population aged under 40, the percentage of mobile-only and of prepaid customers are included in our regression. We expect that a higher share of mobile-only customers in one country will lead to lower fixed-line voice traffic volumes. ϵ_{it} is an error term and (1- ψ) and the αs are parameters to be estimated.
Due to the structure of our panel dataset, the well-known Arellano-Bond-estimator is not applicable, because it is designed for short panels characterized by a large cross section dimension. Applying extensive simulation studies, Judson and Owen (1999) show that it is reasonable to apply standard fixed effects techniques for long panels, whereas the Arellano-Bond GMM-type estimator may be seriously biased in panels characterized by long time dimensions. We follow their suggestions and estimate a dynamic fixed effects panel model using the Newey-West-procedure to avoid distortions in standard errors due to autocorrelation and heteroscedasticity (Wooldridge, 2010, p. 310 et seqq.).
To prevent spurious regressions, we apply panel unit root tests for all variables in our dataset. We find that only the variables $pen_{wireless}$, $pen_{wireline}$, ftf, gdp and $perc_{mobonly}$ are non-stationary and all integrated of order one. Hence, cointegration relationships cannot be present in our dataset, because our dependent variable $traffic_{fix}$ on the left hand site is I(0)[4]. However, cointegration would not cause spurious correlation, but one would have to estimate error correction models to be able to disentangle short- and long-run effects (Engle/Granger, 1987). As will be discussed in the next section, we also take possible endogeneity problems into account by using instrumental variable techniques. Endogeneity problems may arise when estimating demand functions as quantities and prices can influence each other simultaneously.

3.5 Empirical Results

To solve possible endogeneity problems, we instrument the first lag of our dependent variable, the penetration rates and the usage prices. Hence, we use further

[4]For further information see Hamilton (1994). The corresponding test statistics can be found in table 3.5 of the appendix.

lags of the variables as well as termination rates as instruments. Termination rates are an important (variable) cost factor for the operators, which occur particularly for off-net calls. The national regulatory authority in each country determines the termination charges, which can therefore be considered as exogenous. This assumption can be criticized as the decision of the regulator may be affected by other factors such as changes in volumes. However, this effect appears more likely in the long-run, but can be assumed to be exogenous in the short-run due to the structure of our regression model. Nevertheless, termination rates are the only cost shifter that directly influences the variable costs and can be observed by econometricians. We lag all termination rates by one quarter since reductions in termination rates are not directly passed on to the customers (Briglauer et al., 2011, p. 13).[5] By applying overidentification tests, we test for the exogeneity of our instruments and we cannot reject the null hypothesis stating exogeneity of our instruments. Table 3.2 illustrates our results using a linear time trend (column 2) or quarterly time dummies (column 3).[6] As a further robustness check, we also estimate our model without penetration rates due to their insignificance. The results do not change significantly and can be found in table 3.7 in the appendix. For both regressions, we identify statistically significant effects at a 5% or higher significance level from the lag of our dependent variable ($traffic_{fix_{it-1}}$), the current fixed-line price ($p_{fix_{it}}$), the current mobile price ($p_{mob_{it}}$), the percentage of mobile-only users ($perc_{mobonly_{it}}$) and the percentage of prepaid customers ($perc_{prepaid_{it}}$). All significant variables have the expected signs.

Regarding the regression using a linear time trend (second column), we find that the lag of the national outgoing fixed-line traffic volume has a large positive effect (+ 0.71) on the current fixed-line traffic volume, which is significant at a 1% significance level. According to our model specification, the coefficient of $traffic_{fix_{it-1}}$ equals (1 - ψ) and we can calculate ψ.

The own-price elasticity of the fixed-line price on the fixed-line traffic volume

[5] Termination rates do not change every quarter. Furthermore, if there is no change in one period, it is not problematic as the lag then equals the current value. If the termination rate changes, we control for this change.

[6] The first stage F-statistics and the corresponding p-values can be found in table 3.6 in the appendix. Furthermore, the pairwise correlations between all variables used are summarized in table 3.8.

Table 3.2: Empirical Results

Variable	with time trend	with time dummies
$traffic_{fix_{it-1}}$	0.7062***	0.6587***
	(0.0921)	(0.0995)
$p_{fix_{it}}$	- 0.1378**	- 0.1661**
	(0.0624)	(0.0661)
$p_{mob_{it}}$	0.1250**	0.1256***
	(0.0520)	(0.0483)
$pen_{wireless_{it}}$	0.1137	0.1566*
	(0.0939)	(0.0928)
$pen_{wireline_{it}}$	0.1755	0.0843
	(0.2328)	(0.2092)
gdp_{it}	- 0.0321	- 0.1407
	(0.0708)	(0.0935)
$perc_{mobonly_{it}}$	- 0.3036***	- 0.3559***
	(0.1043)	(0.1085)
$perc_{prepaid_{it}}$	- 0.3922**	- 0.5212***
	(0.1766)	(0.1813)
$perc_{under40_{it}}$	- 2.2370	- 1.2126
	(1.6979)	(1.4815)
pop_{it}	- 0.0424	- 0.4778
	(0.5719)	(0.6148)
d_{Q2}	- 0.0331***	
	(0.0054)	
d_{Q3}	- 0.0626***	
	(0.0078)	
d_{Q4}	0.0639***	
	(0.0134)	
trend	- 0.0059*	
	(0.0033)	
time dummies	no	yes
ψ	0.2938	0.3413
R^2	0.9399	0.9465
N	275	275
Hansen's j	2.0270	1.5690
p-value	0.5668	0.6664

$*$,$**$,$***$ indicate statistically significant on the 10%, 5%, and 1% level
Heteroscedasticity-Autocorrelation robust standard errors in parenthesis

is negative, as expected. In the short run, a 1% increase in the fixed-line price leads to a 0.14% decrease in the fixed-line traffic volume, whereas the fixed-line traffic volume declines by 0.1378/(ψ = 0.2938) $\approx$ 0.47% in the long run. The cross-price elasticity of the mobile call price is positive: A decrease in the current mobile price ($p_{mob_{it}}$) causes a decrease in the fixed-line traffic volume. In the short run, a 1% reduction of the mobile price indicates a 0.13% decline in the fixed-line traffic volume. In the long run, the cross-price elasticity is given by 0.1250/(ψ = 0.2938) $\approx$ 0.43. One should note that this finding is quite a strong indicator of fixed-mobile substitution on the traffic level, especially in the long run. In addition, the percentages of the population using only mobile services and/or prepaid contracts have the expected negative effect on the current fixed-line traffic. The results are robust when using time dummies instead of a linear trend (column 3).
Overall, our findings provide evidence for short- and long-run call substitution from fixed to mobile services. The effects found are larger than in other studies. The main reason might be the actuality of our dataset. In addition, we apply the Sargan/Hansen's j test. With p-values of 0.57 and 0.67, we cannot reject the null hypothesis stating the validity of our specifications. The following section concludes.

3.6 Conclusion

The chapter analyzes FMCS in 16 mainly Western European countries employing quarterly data from 2004 to mid-2010. We use fixed-line voice traffic volumes in each country and estimate the effects of the current fixed and mobile prices on the national outgoing fixed-line voice traffic volumes. Due to our dynamic setup, we are able to estimate short- and long-run elasticities. We find the own-price elasticities of the fixed-line price on the fixed-line traffic volume to be in a range between -0.14 and -0.17 in the short run, and between -0.47 and -0.49 in the long run. The cross-price elasticities of the mobile price on the fixed-line traffic volume are lower, within the range of +0.13 in the short run and between +0.37 and +0.43 in the long run.
Possible endogeneity problems in our econometric model are solved by instrumenting prices and penetration rates with own lags and a set of different termi-

nation rates. Our elasticities are all statistically significant on a 5% significance level and diverge from other research projects analyzing cross price elasticities for fixed-line call demand. Ingragam and Sidak (2004) report a small, but significant cross-price elasticity of +0.02. Ward and Woroch (2004) find cross-elasticities to lie in between +0.22 and +0.33. Briglauer et al. (2011) find no significant short-run cross-price elasticity, but the long-run cross-price elasticity at +0.50 is almost as large as that in our findings.

To sum up, our study supports the general assumption that call substitution from fixed to mobile services is prevailing with time. Additionally, the demand elasticities are, as expected, larger in the long run as consumers' calling habits will only adjust slowly.

Our results have an ample impact with regard to regulation. Although we show that fixed and mobile markets are converging and becoming closer substitutes, regulatory obligations in the two markets are still quite different. In conjunction with the estimation results the suitability of the definition of separate fixed and mobile markets in the current European regulatory framework may need to be reconsidered for future telecommunications regulation.

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Appendix

Table 3.3: Countries included in the empirical study

Country	Period	Country	Period
Austria	Q1 2005 - Q2 2010	Hungary	Q1 2005 - Q2 2010
Belgium	Q1 2004 - Q2 2010	Italy	Q1 2005 - Q2 2010
Czech Republic	Q1 2005 - Q2 2010	Netherlands	Q1 2005 - Q2 2010
Denmark	Q1 2005 - Q2 2010	Poland	Q1 2005 - Q2 2010
Finland	Q1 2004 - Q2 2010	Portugal	Q1 2004 - Q2 2010
France	Q1 2004 - Q2 2010	Spain	Q1 2004 - Q2 2010
Germany	Q1 2004 - Q2 2010	Sweden	Q1 2004 - Q2 2010
Greece	Q1 2004 - Q2 2010	UK	Q1 2004 - Q2 2010

Table 3.4: Definition of the variables used

Variable	Description of variables
$traffic_{fix}$	National outgoing fixed-line voice traffic volume (in mio.)
p_{fix}	Fixed-line price per minute calculated as fixed-line voice revenue (without interconnect payments) divided by total outgoing fixed-line traffic, given in USD PPP
p_{mob}	Mobile price per minute calculated as mobile voice revenue (without interconnect payments) divided by total outgoing mobile traffic, given in USD PPP
$pen_{wireless}$	Mobile penetration rate
$pen_{wireline}$	Fixed-line pentration rate
mtr	Mobile termination rates, given in USD PPP
ftf	Fixed-to-fixed termination rates, given in USD PPP
ftm	Fixed-to-mobile termination rates, given in USD PPP
gdp	Gross national product, given in USD PPP (in bn.)
$perc_{mobonly}$	Percentage of the population using only mobile, but no fixed-line telephony
$perc_{prepaid}$	Percentage of prepaid customers among all mobile subscribers (excludes customers who have not used their mobile account for more than three months)
$perc_{under40}$	Percentage of the population aged under 40
pop	Population (in mio.)

Table 3.5: Maddala - Wu Unit Root Tests

Unit root tests	Levels	1st differences
$traffic_{fix}$		
χ^2	164.1328	438.5566
$Prob > \chi^2$	0.0000	0.0000
p_{fix}		
χ^2	101.7945	338.4291
$Prob > \chi^2$	0.0000	0.0000
p_{mob}		
χ^2	69.9723	371.488
$Prob > \chi^2$	0.0001	0.0000
$pen_{wireless}$		
χ^2	14.1420	199.4026
$Prob > \chi^2$	0.9973	0.0000
$pen_{wireline}$		
χ^2	26.0979	201.0629
$Prob > \chi^2$	0.7593	0.0000
mtr		
χ^2	63.8101	364.4442
$Prob > \chi^2$	0.0007	0.0000
ftf		
χ^2	16.5843	195.7924
$Prob > \chi^2$	0.9888	0.0000
ftm		
χ^2	57.0201	281.2384
$Prob > \chi^2$	0.0042	0.0000
gdp		
χ^2	10.1392	142.395
$Prob > \chi^2$	0.9999	0.0000
$perc_{mobonly}$		
χ^2	41.7303	304.3285
$Prob > \chi^2$	0.1165	0.0000
$perc_{prepaid}$		
χ^2	58.9761	220.2582
$Prob > \chi^2$	0.0025	0.0000
$perc_{under40}$		
χ^2	182.6028	431.2025
$Prob > \chi^2$	0.0000	0.0000
pop		
χ^2	76.1572	579.3324
$Prob > \chi^2$	0.0000	0.0000

Table 3.6: Instrumental variables: 1st Stage F-statistics and p-values

Variable	F-statistic	P-value
Regression with linear time trend (column 2)		
$traffic_{fix_{it-1}}$	74.83	0.0000
$p_{fix_{it}}$	38.03	0.0000
$p_{mob_{it}}$	37.32	0.0000
$pen_{wireless_{it}}$	30.49	0.0000
$pen_{wireline_{it}}$	76.85	0.0000
Regression with time dummies (column 3)		
$traffic_{fix_{it-1}}$	66.50	0.0000
$p_{fix_{it}}$	36.47	0.0000
$p_{mob_{it}}$	40.71	0.0000
$pen_{wireless_{it}}$	31.46	0.0000
$pen_{wireline_{it}}$	69.91	0.0000

Table 3.7: Empirical Results without penetration rates

Variable	with time trend	with time dummies
$traffic_{fix_{it-1}}$	0.7927***	0.7621***
	(0.0665)	(0.075)
$p_{fix_{it}}$	- 0.0920**	- 0.1046**
	(0.0469)	(0.0501)
$p_{mob_{it}}$	0.0860**	0.0916**
	(0.0417)	(0.0423)
gdp_{it}	0.0138	0.1034
	(0.0678)	(0.0897)
$perc_{mobonly_{it}}$	- 0.2561***	- 0.2782***
	(0.0940)	(0.0947)
$perc_{prepaid_{it}}$	- 0.2510*	- 0.3378**
	(0.1348)	(0.1433)
$perc_{under40_{it}}$	- 2.6886**	- 2.4674**
	(1.2567)	(1.1427)
pop_{it}	- 0.2320	- 0.8232
	(0.4972)	(0.5595)
d_{Q2}	- 0.0348***	
	(0.0055)	
d_{Q3}	- 0.0595***	
	(0.0081)	
d_{Q4}	0.0748***	
	(0.0104)	
trend	- 0.0042**	
	(0.0020)	
time dummies	no	yes
ψ	0.2073	0.2379
R^2	0.9384	0.9435
N	284	284
Hansen's j	0.7779	0.0044
p-value	0.3778	0.9474

$*$,$**$,$***$ indicate statistically significant on the 10%, 5%, and 1% level
Heteroscedasticity-Autocorrelation robust standard errors in parenthesis

Table 3.8: Pairwise Correlation

	$traffic_{fix}$	p_{fix}	p_{mob}	$pen_{wireless}$
$traffic_{fix}$	1.0000			
p_{fix}	0.4863*	1.0000		
p_{mob}	0.1033*	0.4369*	1.0000	
$pen_{wireless}$	- 0.1090*	- 0.0489	- 0.4651*	1.0000
$pen_{wireline}$	0.4522*	- 0.5514*	- 0.0249	- 0.3896*
gdp	0.9788*	- 0.4640*	0.0423	- 0.0808
$perc_{mobonly}$	- 0.4930*	0.5492*	- 0.1783*	0.2490*
$perc_{prepaid}$	0.1704*	0.3853*	0.4435*	0.1688*
$perc_{under40}$	- 0.2938*	0.4582*	0.2834*	- 0.4698*
pop	0.9561*	- 0.3646*	0.1078*	- 0.1170*

	$pen_{wireline}$	gdp	$perc_{mobonly}$	$perc_{prepaid}$
$pen_{wireline}$	1.0000			
gdp	0.3648*	1.0000		
$perc_{mobonly}$	- 0.6993*	- 0.4279*	1.0000	
$perc_{prepaid}$	- 0.1107*	0.1448*	- 0.0910	1.0000
$perc_{under40}$	0.1142*	- 0.2873*	0.0311	0.0349
pop	0.2954*	0.9728*	- 0.3823*	0.2151*

	$perc_{under40}$	pop		
$perc_{under40}$	1.0000			
pop	- 0.2014*	1.0000		

* significant on 5% level or higher

Chapter 4

Analyzing Competitive Effects of Exclusively Dealt iPhones in European Mobile Markets

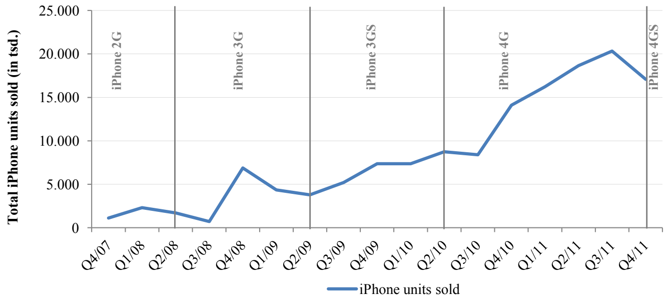
4.1 Introduction

Exclusive dealing is a widely discussed issue within competition economics. The concerns arising from this practice are that competitors might be excluded from the market and, thereby, competition intensity in markets with exclusive contracts is reduced (Whinston, 2008). Based on the recent example of the iPhone, we are able to create a unique dataset and empirically study the effects of exclusive dealing.

In 2007, Apple introduced the first generation of its iPhone in the US and in some major European countries, including Germany, France and the United Kingdom. By the end of 2008, the iPhone was available in almost all European countries.

The iPhone revolutionized mobile markets. Queues of people were waiting outside of Apple flagship stores all over the world in order to be one of the first to own the device. Network operators, such as T-Mobile Germany for instance, reported that they had won 70.000 iPhone subscribers during the first 3 months after its introduction (Telekom, 2007). Figure 4.1 shows the development of the iPhone units sold globally between 2007 and 2011. It is obvious that the iPhone sales per quarter have heavily increased over time and about 20 million units were sold in the third quarter of 2011 alone.

Figure 4.1: Development of the iPhone units sold globally



Source: Apple, 2012

Next to new technological features, a main innovation of the iPhone is its exclusive distribution. In many countries, Apple signed contracts with only one or two network operators, who then held the right to exclusively[1] sell the device in their domestic market. In many cases, the exclusive partner was the market incumbent. Although the negotiated conditions between Apple and the network operators were kept secret, US market analysts estimate that in order to get the exclusive right, network operators had to pay up to 30 percent of their revenues gained through iPhone customers to Apple (Mobile Market Development Ltd., 2008, p. 22). Nevertheless, the iPhone was sold non-exclusively in some European countries, mainly due to regulatory concerns. Figure 4.2 gives an overview of the different situations in European telecommunications markets between 2007 and 2010.

In countries with two exclusive dealers, the second partner was usually licensed later than the first one. Additionally, the duration of the contracts between Apple

[1]The exclusivity is controlled by using the so called SIM lock technology. This feature is built into mobile phones by the manufacturers and enables network providers to restrict the use of these phones to their own specific network. Thus, customers cannot use the SIM card of another, non-exclusive provider with the iPhone. In addition, the iPhone prevents access to its media player and web features unless it has also been activated as a phone with an authorized carrier. Nevertheless, so called jailbreak software has been developed by hackers to illicitly unlock the iPhone. We will not further discuss these practices as we cannot observe the impact of jailbreaking. However, if the assumption holds that the share of manipulated devices is equally large in all countries, jailbreaking will have no effect on our results.

Figure 4.2: The situation in Europe: Exclusive contracts with Apple (2007-2010)

Exclusive arrangements with SIM-LOCK		
Countries with one exclusive dealer	Countries with two exclusive dealers	Country without exclusive dealers or without SIM-Lock
▪ Germany (T-Mobile) ▪ Finland (TeliaSonera) ▪ Netherlands (T-Mobile) ▪ UK (Telefónica o2)	▪ Austria (T-Mobile & Orange) ▪ Norway (Netcom & Telenor) ▪ Portugal (Vodafone & Optimus) ▪ Sweden (Netcom & Telenor) ▪ Switzerland (Swisscom & Orange) ▪ Denmark (TeliaSonera & Telenor) ▪ Poland (T-Mobile & Orange)	▪ Belgium ▪ Czech Republic ▪ France ▪ Greece

Source: Information collected on various webpages, 2012

and particular providers was unclear and unknown by the public. However, all exclusive iPhone contracts came to an end in Europe, by 2010 at the latest.[2]

In this chapter, the effects of the exclusive rights held by certain operators between 2007 and 2010 on the competition level in European mobile markets will be analyzed. Therefore, we construct a panel dataset which comprises information on the mobile network operators of 15 European countries from 2003 to 2011, on a quarterly basis.

Usually, one would consider a difference-in-difference or even a triple difference approach to analyze our specific research question. However, it turns out that these methods do not lead to satisfying results as the size of the treatment group is too small in comparison to the size of the control group.[3] Hence, we apply dynamic fixed effects panel data techniques, incorporating a dummy equal to 1, if an operator holds the right to exclusively sell the iPhone in period t.

The chapter is structured as follows: Section 4.2 gives an overview of the existing literature on exclusive dealing and on the demand for iPhones. In chapter 4.3, the dataset is explained. Section 4.4 and 4.5 describe our model specification and our empirical results. In section 4.6, a conclusion is drawn.

[2]A list of the current sellers of the iPhone can be found on Apple's website.

[3]See, for instance, Bertrand et al. (2004) and Donald/Lang (2007) for a detailed discussion of potential problems with difference-in-difference estimates.

4.2 Economic Background

There are many economic papers studying the effects of exclusive dealing[4]. One strand of literature focuses on investment incentives in the presence of exclusive dealing (see for instance Segal/Winston, 2000; De Fontenay et al., 2010), another on the overcoming of contractual opportunism (see for example McAffee/Schwartz, 1994 & 2004). In addition, there are various papers exploring competitive effects of compatibility within mix-and-match markets[5]. However, most of these studies focus on exclusive dealing between vertically integrated firms (see for instance Economides/Salop, 1992; Matutes/Regibeau, 1988 & 1992). Furthermore, some related papers have a different understanding of the exclusive arrangement and its design. For instance, Schwartz (1987) assumes that the retailers decide on the exclusive contract and thus manufacturers compete for the privilege to be chosen. This assumption might hold for the situation before the introduction of the iPhone, in which mobile providers were in a position to dictate which devices they allowed on their network, as well as which software was put on their devices, but this is definitively not the case for the iPhone (Detecon, 2010).

Additionally, many studies compare a duopoly of two manufacturers selling to one retailer with a situation in which each manufacturer sells to one retailer (see for instance Lin, 1990; O'Brien/Shaffler, 1993; Rey/Stiglitz, 1995). This is not the relevant case in our specific setup, as we want to investigate the effects of an asymmetric situation in the downstream retail market, in which some retailers sell all x products and other retailers are only able to offer x-1 products.

Therefore, research investigating asymmetric exclusivity arrangements between non-integrated firms is most relevant for our purpose. However, this strand of literature is still maturing, and to the best of our knowledge only two theoretical articles exist nowadays.

As one of the first, Hermalin and Katz (2010) study theoretically the effects of exclusive dealing between non-integrated firms, which produce complementary

[4] See also Belleflamme/Peitz, 2010, p. 443 et seqq. for a detailed discussion of exclusive dealing.

[5] Mix-and-match markets describe markets in which two complements are consumed within a fixed proportion. For example, a mobile consumer has to choose a mobile network carrier and a mobile handset. Comparability of complements then enables consumers to choose between different systems (Hermalin/Katz, 2010).

goods such as wireless carriers and producers of mobile devices. Their central finding is that exclusive dealing can relax price competition. In detail, assuming competition between two undifferentiated platforms (e.g. network operators) which both provide the same two applications (e.g. handsets), leads to zero profit according to the Bertrand paradox. With the right to exclusively distribute applications, platforms' profits are increasing, but still remain lower than the profit a monopolist would generate. Additionally, in the asymmetric duopoly case, where one operator sells both applications and the other only one, the profit of the operator holding the exclusive right is higher than the profit of its competitor. In their setup, the consumer surplus is greatest in the mix-and match case where both platforms provide both applications.

Chen and Fu (2012) analyze the ramifications of exclusive arrangements with comparable goods on market competition and consumer & social welfare. Looking at a monopolistic manufacturer (e.g. Apple), two competitors in the retail market (e.g. two network providers) and the end consumers in a four-step procedure, they find that the manufacturer can raise its profit through exclusive arrangements assuming the manufacturer engages a so called demarginalization strategy[6]. Their findings also indicate that the exclusive right enables the chosen company to generate higher profits than its competitor due to a larger market share. In contrast to Hermalin/Katz (2010), Chen/Fu (2012) find that the total consumer surplus is increasing when exclusivity is in place.

There are also two empirical working papers looking at the iPhone. Using US and Canadian survey data for 2008 and 2009, Zhu et al. (2011) study consumers' purchase decisions of handsets and service providers. Assuming a Stackelberg game between the handset manufacturer and the service provider and using the demand estimates from the last step, they recover markups for the player in the market. Afterwards, they simulate the counterfactual situation in which the iPhone would

[6]Demarginalization means that the monopolistic manufacturer strategically underprices its value-adding good and sells it at marginal costs. This indicates that the producer earns zero profit with its produced good. However, this foregone revenue is compensated by a higher bid at the auction. The reasoning behind is that a lower price will boost demand and therefore will allow the retail seller (e.g. net provider) to generate extra profits in the downstream primary-goods market. Hence, the net provider will make a higher bid (Chen/Fu, 2012). Being able to engage this strategy, McGuire and Staelin (1983) find that manufacturers therefore often prefer non-integrated relationships with the retailer over vertical integration.

have been available for all carriers. Their findings indicate that consumer welfare is lower when the iPhone is sold exclusively, as compared to the counterfactual situation.

Sinkinson (2011) empirically investigates the incentives of Apple to exclusively distribute the iPhone. His findings indicate that exclusive arrangements can maximize the joint profit of the manufacturer and the retailer if the price elasticity of the manufacturer's product is relatively low compared to the elasticity of the downstream carrier. Additionally, different price elasticities among downstream providers lead to different valuations for the exclusivity. For instance, AT&T had the greatest incentive of all US operators to exclusively sell the iPhone.

To conclude, related research finds that the operator engaged in an exclusive arrangement generates a higher profit than its competitors. The findings concerning the consumer welfare show a rather mixed picture. While Hermalin/Katz (2010) and Zhu et al. (2011) conclude that the exclusivity of the iPhone leads to decreasing consumer surplus, the results of Chen/Fu (2012) are controversial.

In our dataset, we can neither observe the strategy of the manufacturer, Apple, nor the costs of the different net operators. We ,therefore, concentrate on downstream competition in the retail market and empirically analyze the effect of the iPhone exclusivity on operators' revenues per user[7]. Based on the existing theoretical and empirical literature, we expect that exclusive dealers can generate higher revenues than their competitors. To the best of our knowledge, there is no other empirical research paper investigating competitive effects of the asymmetric exclusivity arrangements between Apple and various mobile operators using panel data. Moreover, no paper focuses on Europe. In the next sections, the dataset and the empirical specification will be explained.

4.3 Data

Our dataset contains information on 55 mobile network operators from 15 European countries between the fourth quarter of 2003 and the third quarter of 2011. Our main data sources are Analysys Mason's Telecoms Market Matrices for West-

[7] We use the ARPU because we have no information on operators' costs and are therefore unable to calculate operators' profits.

ern, Central and Eastern European countries. From these datasets, we obtain information on the average revenue per subscriber, mobile voice and data traffic volumes, fixed and mobile call prices, the number of mobile subscribers and their split into prepaid and postpaid subscribers. Moreover, information on the monthly churn rates, the mobile data revenues and the GDP per capita is found in Merrill Lynch's Wireless Matrix. We also incorporate data of EUROSTAT on the age structure of the population. Furthermore, we construct a variable on population density employing data from the Worldbank. Table 4.1 illustrates the descriptive statistics for all variables used in our analysis.[8]

Table 4.1: Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
$ARPU$	1527	33.52	8.71	3.63	75.24
$churn$	1151	0.02	0.01	0.01	0.05
$early$	1527	0.65	0.48	0.00	1.00
$exclusive$	1527	0.09	0.29	0.00	1.00
gdp_{pc}	1527	31,550.14	8,363.75	12,890.30	55,914.56
$merge$	1527	0.03	0.18	0.00	1.00
p_{fix}	1527	0.06	0.02	0.01	0.15
p_{mob}	1527	0.19	0.09	0.06	0.53
$perc_{20to34}$	1527	0.20	0.02	0.18	0.24
$perc_{postpaid}$	1527	0.56	0.19	0.00	1.00
$perc_{prepaid}$	1527	0.44	0.19	0.00	1.00
$pop_{density}$	1527	161.76	122.98	15.09	492.62
sub	1527	7,000,202	7,654,758	25,000	37,100,000
$traffic_{mou}$	1527	2,285.12	2,490.35	2.63	12,632.00
$traffic_{sms}$	1527	1,364.12	2,043.13	1.00	15,402.00

$ARPU$ describes the average monthly service revenue per subscriber of a mobile provider. $Churn$ stands for the monthly churn rate, i.e. the rate of contract cancellations in relation to all contracts of an operator. $Early$ is a dummy variable equal to 1 if an operator entered the market as the first or second mover. $Exclusive$ represents a dummy variable equal to 1 if a net provider holds the exclusive right to sell the iPhone in this specific period. The variable gdp_{pc} measures

[8]Additionally, the definition of the variables used and their pairwise correlations can be found in table 4.5 and 4.6 in the appendix.

the GDP per capita. $Merge$ is a dummy variable controlling for mergers between operators. P_{fix} and p_{mob} represent the prices of fixed and mobile calls per minute. $Perc_{20to34}$ refers to the percentage of the population aged between 20 and 34. The variables $perc_{postpaid}$ and $perc_{prepaid}$ show the proportion of postpaid and prepaid subscribers in relation to all mobile subscribers (sub) of one operator, respectively. It should be noticed that mobile subscribers which were inactive for more than three months are subtracted from the data by Analysys Mason. $Pop_{density}$ stands for the population density and is constructed by dividing the total population of a country by its total area in square meters. The variable $traffic_{mou}$ measures the total outgoing mobile network traffic in millions of voice minutes. $Traffic_{sms}$ depicts the total amount of text messages sent out in one mobile network (in millions). We also incorporate quarterly time dummies d_2 to d_{35}. All price variables ($ARPU$, gdp_{pc}, p_{fix}, p_{mob}) and $pop_{density}$ are measured in logarithms in order to interpret them as elasticities. Furthermore, all price variables are measured in USD adjusted by purchasing power parities (Source: OECD) to add in international comparison.

4.4 Model Specification

In this chapter, we study the effects of the exclusivity on the ARPU by using dynamic panel data techniques[9]. The inclusion of the lagged dependent variable ARPU as explanatory variable enables us to allow for some form of autocorrelation. We assume partial adjustment of our dependent variable, and hence the coefficient of $ARPU_{i,t-1}$ in equation 4.2 measures the degree of adjustment per period (Arellano, 2003, p. 129 et seqq.). The economic idea behind the dynamic setup will be explained below.

In addition, the analysis of the exclusivity effects leads to some economic and econometric problems which have to be solved. First of all, the selection of exclusive partners by Apple does not evolve from a random process. More likely, Apple's decision on who to choose as exclusive partners depends on certain char-

[9]We also estimate our model statically, but it turns out that the Gauss-Markov assumption of uncorrelated error terms does not hold any longer. Therefore, we conclude that the dependent variable is time persistent and we include the lagged dependent variable as a regressor.

acteristics of the net providers, such as the total number of network subscribers, the share of postpaid customers and traffic volumes. Apple's reasoning probably includes the fact that an operator with a larger number of subscribers is helpful to reach a wider customer base; postpaid subscribers have, on average, a higher willingness to pay for mobile services, and consumers with high usage volumes are more likely to pay for new services and more expensive handsets with special features. To sum up, the probability of a successful product launch and development increases with special characteristics of the chosen operator. In addition, Sinkinson (2011) has shown that certain network operators, most likely the early entrants, have higher incentives to conclude an exclusivity contract. Reasons might be that early movers have, in general, the advantage of serving more business and high-usage customers (Gruber, 2005, p. 80), who are more likely to demand the iPhone. Thus, this non-random selection has to be taken into account in order to prevent a positive selection bias. This is done by using the standard Heckman correction (Heckman, 1979). Technically, we first run a random effects probit regression on the probability of an operator to be selected as exclusive partner. We assume that the probability of a net provider to be privileged depends on the following equation:

$$\begin{aligned} Prob(exclusive_{i,t}) = \alpha + \beta_1 sub_{i,t} + \beta_2 traffic_{mou_{i,t}} + \beta_3 perc_{postpaid_{i,t}} \\ + \beta_4 traffic_{sms_{i,t}} + \beta_5 early_{i,t} + \epsilon_{i,t}. \end{aligned} \tag{4.1}$$

We expect all five beta coefficients to be positive. Afterwards, we calculate the inverse mills ratio as the reciprocal of the fitted values, which then serves as a variable correcting for a possible selection bias in the regression on the ARPU. Analyzing the determinants of the ARPU, we specify the following equation:

$$\begin{aligned} ARPU_{i,t} = \beta_1 ARPU_{i,t-1} + \beta_2 p_{mob_{i,t}} + \beta_3 churn_{i,t} + \beta_4 exclusive_{i,t} \\ + \beta_5 perc_{prepaid_{i,t}} + \beta_6 mills_{ratio_{i,t}} + \sum_{k=7}^{K} \beta_k x_{k_{i,t}} + \epsilon_{i,t}. \end{aligned} \tag{4.2}$$

We expect the first lag of our dependent variable ARPU to have a positive influence on its current level, because if the ARPU was higher in the last quarter, it will be higher today due to consumption habits and sticky call prices. The service revenue mainly depends on subscribers' overall usage and call prices. First, the current usage level of an individual consumer will probably be linked to the usage level of the previous period.[10] Secondly, the price level in one period will be, at least to some degree, related to the price in the period before. One reason might be that postpaid contracts usually run for one or two years, during which prices are fixed. In addition, several tariffs include flat rates to specific or even all networks, which then influence the customers' consumption patterns and determines the expenditures per month. Hence, the ARPU adjusts only partially within one period and therefore only converges to a new equilibrium in the long-run.[11]

The current mobile call price should have a positive influence on the current ARPU because a higher call price leads to a higher average revenue, assuming all other variables to be fixed. The churn rate is expected to have a negative effect on the ARPU, as a high churn rate is likely to be related to a larger number of consumers who are on average more open to competitive offers than customers in general (see also McCloughan/Lyons, 2006). The dummy variable exclusive, which is equal to one if operator x exclusively sells the iPhone in period t, has to be positive in order to find an advantage of the operators holding the exclusive right to sell the iPhone in comparison to its competitors. The relationship between the share of prepaid customers and the ARPU is expected to be negative. A higher percentage of prepaid customers, who tend to be low-usage consumers due to the specific prepaid tariff structures (i.e. low subscription fee and relatively high call prices), indicates that the operator's ARPU is likely to be lower. To find a positive selection bias, the coefficient of the $mills_{ratio}$ has to be positive and significant. The term $x_{k_{i,t}}$ includes all additional explanatory variables, such as the population density, the GDP per capita, the age structure of the population and a dummy controlling for mergers between operators. In addition, the fixed-line price is included as prices for complementary or substitute goods may have significant effects on the demand for mobile services. ϵ_{it} is an error term and the βs are parameters to be estimated.

Preventing spurious regression, we apply panel unit root tests for all variables in our dataset. We find that our dependent variable $ARPU$ on the left hand side is

[10] See Taylor (1994) for more details.
[11] See Deaton/Muellbauer (1980) for further details.

integrated of order zero.[12] Thus, cointegration relationships cannot be present in our dataset. In fact, cointegration would not cause spurious correlation, but one would have to estimate error correction models to be able to disentangle short- and long-run effects (Engle/Granger, 1987).

However, in our regression on the ARPU, we still face difficulties. We cannot use the well-known Arellano-Bond estimator as it might be seriously biased in panels with large time dimensions. Applying extensive simulation studies, Judson and Owen (1999) show that in these cases, it is thus reasonable to use standard fixed effects techniques. Following their suggestions, we estimate a dynamic fixed effects panel model using the Newey-West-procedure to avoid distortions in standard errors due to autocorrelation and heteroscedasticity (see Wooldridge, 2010, p. 310 et seqq.).

Furthermore, we have to solve possible endogeneity problems by instrumenting the first lag of our dependent variable $ARPU$ and the mobile call price p_{mob}. Hence, so called Hausman instruments are used.[13] Hausman instruments are preferable in our setup as the instrumentation with further lags in the presence of autocorrelation may lead to inconsistent estimates (Arellano/Bond, 1991, p. 278)[14]. Summarizing our methodology, we proceed in three steps:

(i) To begin, we run the random effects probit regression on the probability of being selected by Apple as exclusive partner. Afterwards, we calculate the fitted values and the inverse mills ratio.

(ii) The analysis of the ARPU is divided into two stages. In this second step, we run a first stage instrumental variable regression which also includes the inverse mills ratio.

(iii) In a third step, we run an ordinary second stage fixed effects regression including the predicted values for the endogenous variables which were obtained in the previous step.

In the next section 4.5, the empirical results will be explained.

[12]For further information see Hamilton (1994). The test statistics can be found in table 4.7 in the appendix.

[13]See Hausman (1996) for a detailed description.

[14]See also Nickell (1981) for a detailed discussion in a fixed effects setting.

4.5 Estimation Results

The results of our first step random effects probit regression on the probability of being privileged by Apple can be found in table 4.2. From our regression, we infer that the probability of being chosen is positively influenced by the number of subscribers and the operator's share of postpaid subscribers. Additionally, the total text message traffic has a negative, but quite small effect on the probability of being selected. All variables mentioned above are highly significant, i.e. at a 1% significance level. We then calculate the inverse mills ratio and include it

Table 4.2: 1st Stage Selection Model: Probit Regression

	exclusive
sub	0.0000***
	(0.0000)
$traffic_{mou}$	0.0002
	(0.0002)
$perc_{postpaid}$	7.8010***
	(1.2030)
$traffic_{sms}$	- 0.0003***
	(0.0001)
$early$	0.4480
	(0.8730)
$cons.$	- 12.3200***
	(1.0410)
N	1527
$chi2$	154.3

Standard errors in parentheses are robust against heteroscedasticity and serial correlation. ***, **, and * represent significance at the 1%, 5%, and 10% significance level, respectively.

in our regression on the ARPU. In order to solve possible endogeneity problems, the first lag of our dependent variable and the mobile call price are instrumented by Hausman instruments. Regarding our setup, these instruments are constructed by calculating the average ARPU and the average mobile call price of the other operators in one domestic market. The following table 4.3 shows the correlation between the instrumented variables $ARPU_{t-1}$ and p_{mob} and its instruments iv_{ARPU} and $iv_{p_{mob}}$ respectively. It is obvious that both instruments are significantly correlated with the instrumented variables.

Table 4.4 summarizes the results of our second and third step. In the four columns, we show different specifications with or without the churn rate and the mills ratio. In column 1 the regression includes the churn rate and the mills ratio; in column 2 the mills ratio is dropped; in column 3, we show the results of the regression not including the churn rate, due to 339 missing observations and its insignificance in the previous regression. Column 4 displays the results without the churn rate and the mills ratio. The results are robust as they do not vary significantly across the four different setups. The F-values of the first stage instrumental variable regression can be found in the lower part of table 4.4. We find that the F-values of our Kleibergen-Paap rk Wald F statistic are all larger than the Stock-Yogo critical values. Therefore, we can reject the hypothesis that our instruments are weak and that the bias of our 2SLS approach is greater than 10%.[15]

Table 4.3: Correlation of the Hausman Instruments and the Instrumented Variables

	$ARPU_{t-1}$
iv_{ARPU}	0.6355*
	p_{mob}
$iv_{p_{mob}}$	0.8472*

* significant on 5% level or higher

Referring to our main regressions in column (1) and (3), we find that the ARPU is significantly positively influenced by its first lag, the mobile call price, the percentage of the population aged between 20 and 34 and the exclusivity dummy. Additionally, the ARPU is negatively affected on a 5% significance level or higher by the population density, the percentage of prepaid customers and if a merger between two operators has happened recently. Furthermore, we find evidence for a positive but small selection bias. This becomes also obvious when comparing the magnitudes of the variable exclusive in column (1) and (3) to column (2) and (4), respectively.[16]

[15] See Kleibergen/Paap (2006) and Stock/Yogo (2005) for further details.

[16] We also estimate our model for single countries, i.e. Germany, Finland, the Netherlands and the UK. We expect the coefficient of the variable $exclusive$ to be higher in these countries as only one operator was able to provide the iPhone between 2007 and 2010. Our assumption holds for Finland and the Netherlands, where we find the magnitude of the variable $exclusive$ to be higher

Table 4.4: 2nd Stage Determinants of ARPU: 2SLS FE IV Estimation

	(1)	(2)	(3)	(4)
$ARPU_{t-1}$	0.6910***	0.6850***	0.7470***	0.7430***
	(0.0865)	(0.0880)	(0.0651)	(0.0656)
p_{mob}	0.1190***	0.1220***	0.0891***	0.0905***
	(0.0442)	(0.0445)	(0.0313)	(0.0314)
$pop_{density}$	- 0.4990**	- 0.4950**	- 0.2500*	- 0.2430*
	(0.2020)	(0.2020)	(0.1380)	(0.1380)
gdp_{pc}	0.0179	0.0195	0.0444	0.0455
	(0.0304)	(0.0306)	(0.0279)	(0.0279)
$perc_{20to34}$	2.7520***	2.7780***	2.1210***	2.1330***
	(0.7260)	(0.7350)	(0.6100)	(0.6130)
$churn$	0.4500	0.4570		
	(0.4060)	(0.4070)		
$merge$	- 0.0672***	- 0.0683***	- 0.0570***	- 0.0576***
	(0.0234)	(0.0235)	(0.0207)	(0.0207)
$exclusive$	0.0116**	0.0119**	0.0114***	0.0115***
	(0.0053)	(0.0053)	(0.0044)	(0.0044)
$perc_{prepaid}$	- 0.1450**	- 0.1480**	- 0.1190***	- 0.1210***
	(0.0609)	(0.0617)	(0.0460)	(0.0463)
p_{fix}	- 0.0222*	- 0.0227*	- 0.0195*	- 0.0196**
	(0.0115)	(0.0116)	(0.0099)	(0.0100)
$mills_{ratio}$	0.0032***		0.0033***	
	(0.0010)		(0.0011)	
$d_2 - d_{35}$	*included*			
N	1077	1077	1416	1416
R^2	0.93	0.93	0.93	0.93
$1st\ Stage\ F-values$				
$ARPU_{t-1}$	56.48	56.45	69.45	69.44
p_{mob}	64.98	65.04	107.43	107.51
$Weak\ Identification\ Test\ (Kleibergen-Paap\ rk\ Wald\ F\ statistic)$				
F-value	9.23	9.23	13.68	13.68
$Stock-Yogo\ Weak\ ID\ Test\ Critical\ Values$				
10% max. IV size	7.03			
15% max. IV size	4.58			
20% max. IV size	3.95			
25% max. IV size	3.63			

$*$,$**$,$***$ indicate statistically significant at the 10%, 5%, and 1% level
Heteroscedasticity-Autocorrelation robust standard errors in parenthesis

Our main focus lies on the variable measuring the effect of the exclusivity. We find that the operator's right to sell the iPhone boosts the ARPU on average by approximately 1.2%, holding all other variables fixed. Given the mean monthly ARPU of 33.5 USD PPP, this indicates that an iPhone provider has an on average 0.4 USD PPP higher revenue per subscriber and month. Assuming the average number of subscribers of an exclusive provider of 6.48 million users, this amounts to an about 31.2 million USD PPP higher annual profit per operator solely due to the ability to offer the iPhone exclusively. Keeping in mind, that parts of the revenues gained by iPhone customers have to be paid to Apple, we still presume a fairly large annual increase in profit for the privileged providers. Therefore, we reason that the competitive advantage against operators without the possibility to offer the iPhone is relatively large. In the next section 4.6, a final conclusion is drawn.

4.6 Conclusion

The iPhone is one of the most relevant innovations in the mobile market within recent years. In particular, its innovative distribution has shifted power from the network operators to the handset manufacturers (Rubicon, 2008, p. 5). So, Apple was able to heavily increase its revenue during the last 5 years. In the fourth quarter of 2012 its revenue is 5.8 times larger compared to the revenue in the fourth quarter of 2007, which has made Apple one of the most valuable companies in the world (Apple, 2012).

Nevertheless, network operators engaged in exclusive arrangements have also profited. We looked at the downstream retail market and analyzed the effects of the exclusively dealt iPhones on operators' performance. We find that throughout the period of the exclusivity arrangements, privileged operators have generated an on average about 1.2 percent higher monthly revenue per subscriber compared to their competitors that were unable to offer the iPhone. Taking the average number of subscribers into account, this amounts to an annual profit increase of about 31.2 million USD PPP for operators offering iPhones. Overall, we conclude, in line with the theoretical literature, that asymmetric exclusivity arrangements lead

than in table 4.4. However, the effect remains unclear for Germany and the UK. A possible reason might be the relatively low number of observations when focusing on single countries.

to higher profits of privileged firms compared to their competitors.
Although we cannot directly observe the strategy of Apple, the large increase in Apple's revenue gives at least some evidence to the economic theory indicating that the manufacturer Apple has also profited from its exclusive dealing strategy.
Due to our data structure, we are unable to give advice concerning welfare issues. However, we observe that some European regulatory authorities have interdicted these exclusive arrangements, such as in France (French Competition Council, 2008). However, in 2010, the French Final Court of Appeal decided that the suspension of the exclusive arrangement between Orange France and Apple was not fully justified (French Final Court of Appeal, 2010). This case demonstrates the difficulties that competition authorities face when trying to guarantee the maintenance of an effectively competitive structure. On the one hand, severe treatment of exclusive arrangements could discourage investments and innovation, but on the other hand, exclusivity could distort competition and hence harm consumers (Bougette et al., 2012). Hahn and Singer (2010) therefore believe that an ex post investigation of exclusive arrangements by competition regulatory authorities can swiftly prevent any abuse. In the meantime, the availability of exclusive agreements can accelerate innovations.
However, the existing literature finds different effects of the iPhone exclusivity on consumer welfare. Therefore, future empirical research should further investigate the effects of the iPhone exclusivity on welfare.

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Appendix

Table 4.5: Descriptive Statistics

Variable	Description
$ARPU$	Average revenue per subscriber
$churn$	Monthly churn rate
$exclusive$	Dummy = 1 if operator i holds an exclusive right in period t
gdp_{pc}	GDP per capita
$merge$	Dummy = 1 if two operators merged in period t
p_{fix}	fixed-line call price (in USD PPP)
p_{mob}	Mobile call price (in USD PPP)
$perc_{20to34}$	Percentage of the population aged between 20 and 34
$perc_{postpaid}$	Percentage of postpaid subscribers
$perc_{prepaid}$	Percentage of prepaid subscribers
$pop_{density}$	Population density
sub	Total number of mobile subscribers
$traffic_{mou}$	Total outgoing mobile voice traffic (in millions of voice minutes)
$traffic_{sms}$	Total outgoing text messages (in millions)

Table 4.6: Pairwise Correlation

	$ARPU$	$pop_{density}$	gdp_{pc}	$perc_{20to34}$	$churn$
$ARPU$	1				
$pop_{density}$	0.1415*	1			
gdp_{pc}	-0.0278	-0.2425*	1		
$perc_{20to34}$	0.1472*	0.0365	-0.7439*	1	
$churn$	0.0012	0.1402*	-0.1575*	0.0778*	1
$merge$	-0.0820*	-0.1042*	0.0499	-0.1187*	-0.0435
$exclusive$	-0.1698*	-0.0519*	0.0683*	-0.0257	0.0436
$perc_{prepaid}$	-0.0944*	0.4635*	-0.4248*	0.4086*	0.1864*
p_{fix}	0.2367*	0.2154*	-0.5655*	0.6817*	-0.0337
	$merge$	$exclusive$	$perc_{prepaid}$	p_{fix}	
$merge$	1				
$exclusive$	0.0496	1			
$perc_{prepaid}$	-0.1218*	-0.0394	1		
p_{fix}	-0.1059*	-0.0013	0.2538*	1	

* indicates a 5% significance level

Table 4.7: Maddala-Wu Unit Root Tests

Variable	Test statistic and p-value
$ARPU$	
χ^2	241.8051
$Prob > \chi^2$	0.0000
p_{mob}	
χ^2	165.6830
$Prob > \chi^2$	0.0005
$pop_{density}$	
χ^2	263.8524
$Prob > \chi^2$	0.0000
gdp_{pc}	
χ^2	47.1340
$Prob > \chi^2$	1.0000
$pop_{aged20to34}$	
χ^2	98.0970
$Prob > \chi^2$	0.7847
$churn$	
χ^2	280.7353
$Prob > \chi^2$	0.0000
$merge$	
χ^2	0.6316
$Prob > \chi^2$	1.0000
$exclusive$	
χ^2	7.1995
$Prob > \chi^2$	1.0000
$perc_{prepaid}$	
χ^2	297.8183
$Prob > \chi^2$	0.0000
p_{fix}	
χ^2	322.7890
$Prob > \chi^2$	0.0000

Chapter 5

Irrationality Rings! Experimental Evidence on Mobile Tariff Choices*

5.1 Introduction

The mobile telecommunications market in Germany is characterized by fierce competition among the four network operators T-Mobile, Vodafone, E-Plus and o2. Although the German market is nearly saturated, penetration rates are still increasing. Statistically every German possesses 1.3 mobile contracts today. This development is mainly driven by continuous price cuts, particularly by discount offers (Bundesnetzagentur, 2009, p. 50 et seqq.). Hence, the average revenues per subscriber (ARPU) are decreasing and have declined by approximately 40% between 2003 and 2010 (Merril Lynch, 2010). Thus, new tariff structures become necessary for the network operators to stay profitable.

In Germany, mobile phone tariffs consist of three main components: monthly subscription fees, different usage prices and payments for handsets. Traditionally, the mobile operators used to sell mobile devices with huge discounts in order to accelerate the adoption of mobile services. However, as penetration rates are over 100% since the early 2000s acquiring new customers is not very lucrative and,

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*The research of this chapter is part of a joint project with Julia Graf.

therefore, handset subsidies are very costly for the operators (Kruse et al., 2004). Especially, smaller providers face high average costs due to lower capacity utilization, caused by fewer subscribers and voice volumes. Hence, E-Plus and o2 started to offer tariffs which do not include the corresponding mobile device. The handset 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% of the market (Bundesnetzagentur, 2009), continue to subsidize mobile devices. Overall, many different tariff structures are offered for similar mobile devices. For 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 (o2, 2010; Vodafone, 2010).

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

Within the tariff choices, we find different explanations for irrational decisions. Observing that respondents systematically overestimate their consumption, they are likely to choose cost dominated tariffs. On the other hand, they are generally able and willing to detect optimal tariffs. Furthermore, with increasing usage, consumers' performance improves. Some participants also hold preferences for certain tariff forms, seducing them to choose cost-dominated offers.

The chapter is organized as follows: The next section 5.2 provides an overview of the theoretical background and we derive five testable hypotheses. Section 5.3 explains our experimental design and procedure. Chapter 5.4 summarizes our descriptive and empirical results. Finally, section 5.5 concludes and provides policy implications.

5.2 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 $\pm 20\%$ 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: A significant share of consumers overestimates their actual average consumption within a range of $\pm 20\%$.

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/Morgan (2006) test whether consumers account for total costs, including e.g. 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, respectively a mobile phone bill. Especially, not all mobile phone subscribers are familiar with the interpretation of billing increments. This ability is tested by H_3:

H_3: When faced with a mobile phone bill, consumers make more decision errors than with a given 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), especially these minor cost differences induce a careless behavior of the consumers. This is also proved 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. So far, various articles have been published, 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 mobile phone tariffs with cost caps. In line with these papers, we assume consumers to hold preferences in favor of 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 a bias towards tariffs including handset subsidies.

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

5.3 Empirical Design and Procedure

Our experiment[1] is structured in three distinctive 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 mobile phone bills. If the participants estimate their consumption correctly, meaning within a range of $\pm 20\%$, they receive an extra payment of 1000 taler.[2]

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,[3] which is consequently reduced by the costs for the tariffs they choose.

This part consists of 10 tariff choices. To control for different billing formats[4], the 10 choices are subdivided into two rounds of five choices each. In round 1, participants are told to assume a particular average of monthly outgoing minutes (either 25 min., or 70 min., or 120 min., or 200 min.)[5] and take it as given throughout the next five decisions (choices 1 to 5). The second five questions (choices 6 to 10)

[1] See appendix for further information.

[2] 1000 taler $\triangleq$ 1 Euro.

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

[4] Usually, mobile operators only list the outgoing calls and minutes in the mobile bill, but some also provide the total amount of outgoing minutes.

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

are composed in the same way as the first five questions, but in the second round participants have to calculate their average monthly outgoing minutes themselves. A fictional mobile phone bill is handed out and participants are told to take it as representative for their monthly consumption during the choices 6 to 10. The fictional bills are arranged to again display either 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 mobile phone bill of 120 min. in the second round and vice versa. Those who start with a 70 min. (200 min.) usage in round 1, receive a 200 min. (70 min.) bill in the second choice scenario, respectively. Figure 5.1 illustrates the design of our experiment.

Figure 5.1: 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 the usage, participants are asked to select their optimal tariff out of three given tariffs (T1, T2 and T3). All three tariffs include an identical mobile device and run for 24 months. Each tariff comprises a price for the handset, a monthly subscription fee and a charge per minute for outgoing calls, irrespective of calling on-net or off-net (i.e. fixed-line and other mobile networks). All 10 choices are of the following representative form:

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

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

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

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

The setup of our experiment is explained in the following table 5.1. Part 2 explains the composition of the 5 different questions (choice 1-5 and 6-10, respectively). The first two decisions of each round test participants' logical understanding of the experiment and intend 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 or a handset subsidy. Consumers may either purchase the handset immediately at contract formation (buy now option) or pay the handset price by monthly installments (hire-purchase option). For these two varieties all other tariff components are identical, except for the monthly fixed fee. Contracts with handset subsidies contain no or low expenditures for the handset, as they are included in the relatively higher price of usage.

Table 5.1: Experimental Setup

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

In the third part, participants are asked to give detailed information on personal

characteristics (age, gender, course of studies etc.) and their calling behavior (prepaid contract, provider changes etc.). The final question tests which tariff they have chosen if they were indifferent between two or three options (being listed first, lowest monthly subscription fee etc.).
We invited a total of 87 students and staff members of the Heinrich-Heine-University Duesseldorf via Orsee to our experiment. Participants were asked to bring their last three mobile phone bills for which they received three Euro extra. 27 of the 87 participants brought the requested bills along. However, 31 respondents were prepaid customers and ,thus, do not receive monthly bills at all. All respondents (52% female) use mobile telephony, with an average age of 25.6 years. The market shares of the providers E-Plus (38%), o2 (29%), Vodafone (20%) and T-Mobile (14%) differ from the real market situation in Germany, where T-Mobile and Vodafone hold 36.3% and 32.1% of the market share, respectively. In addition, E-Plus and o2 serve 17.3% and 14.2% 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 E-net[6] customers due to lower price offers. 78% of the participants are very satisfied or satisfied with their provider, but 36% of our respondents have switched their provider within the last two years. This churn rate is compared to the findings of a study on consumers' switching behavior (EU Commission, 2009) relatively high.[7] Our descriptive and empirical results are discussed in the next section 5.4.

5.4 Results

5.4.1 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 81.5% of the participants who brought their bills do not estimate their actual usage correctly. Approximately 60% of them have overesti-

[6]E-Plus and o2 operate in the frequency range of 1800 MHz (E-net), whereas T-Mobile and Vodafone use the frequency range of 900 MHz (D-net).

[7]Additional information regarding the descriptive statistics can be found in table 5.4 in the appendix.

mated their average use. Another interesting fact is that the average prediction error is 320 min. for the respondents who overestimated and only 170 min. for the participants who unterestimated their real consumption. This indicates that the prediction bias is almost twice as large in the overconfident group. 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/Skiera, 2006; Gerpott, 2009).

Finding the cost-minimizing mobile phone tariff involves some sort of calculations. Based on the questions testing their ability/willingness to perform the calculations correctly, H_2 has to be rejected. In our dataset only two out of 87 participants repeatedly select cost dominated tariffs in questions targeting the logical understanding of the experiment (choice 1, 2, 6 and 7). Additionally, from our final question regarding indifferences between different payment forms, we infer that just 2.3% of the respondents choose tariffs because they are listed first. We conclude that non-optimal choices are not caused by lacking understanding/motivation but by biased preferences. However, we offer the participants very stylized forms of mobile phone tariffs, containing only three variables. In reality, consumers are confronted with a lot more criteria including e.g. different prices for on-net and off-net calls and prices for text messages. Therefore, the increasing complexity might however support H_2.

H_3 suggests that participants face difficulties analyzing a mobile phone bill. In order to test H_3, we compare the answers given in the first round for a specific usage (25, 70, 120 or 200 min.) to the choices in the second round. The two rounds just differ in the format the average monthly consumption is presented. In the first round it is given, in the second round participants have to perform calculations themselves. By applying a two-sample Kolmogorov-Smirnov test[8] for all corresponding questions and groups, we cannot reject the null hypothesis, stating that the distributions are equal. We conclude that there are no differences in the

[8]A two-sample K-S test tests for the equality of distributions between two groups. The distribution of each choice for group A (B) is compared with that of the group C (D), respectively. 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/Trenkler (1994)). All K-S tests are summarized in table 5.7 in the appendix.

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.

Based on the results stated above, we match all groups with the same average of 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 5.2 illustrates the reduced setup.

Figure 5.2: Reduced Setup

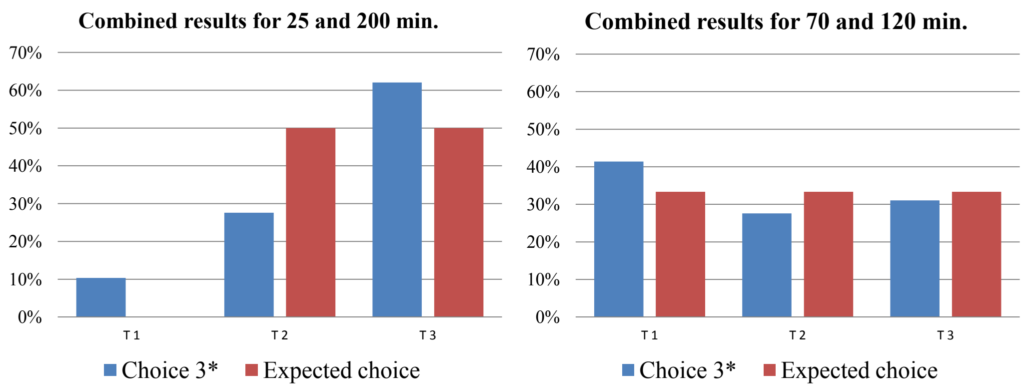
Group	Choices				
	1*	2*	3*	4*	5*
A + C			25 min.		
B + D			70 min.		
C + A			120 min.		
D + B			200 min.		

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, every respondent makes on average 0.95 mistakes answering the 10 questions. The participants of group A and C give wrong answers in 10.5% of all questions, whereas the respondents of group B and D fail in 8.7% 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 0.59 errors compared to 0.43 errors when assuming a 200 min. usage. Despite of a higher error rate, lowest volume users spend on average just 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, mobile phone tariffs in our experiment constitute of and vary in the following price components: monthly subscription fees, usage-dependent prices and handset payments. H_5 states that consumers have strong preferences for specific mobile phone tariffs. 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 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 evenly 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. The left side of figure 5.3, showing the results for the 25 min.

Figure 5.3: Choice 3* - Realized Choices differ from Expected Choices



and 200 min. usage, 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 both alternatives, but 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 dominated, it is chosen by about 10%. This indicates a quite strong bias of some participants towards the cost-dominated tariff T1 including a handset subsidy. Looking at the usage types separately, we find that 15% in the 25 min. and only 6.5% in the 200 min. usage group select the more expensive T1. This again supports somehow H_4.

The preference for subsidies is also confirmed by the results presented on the right side of figure 5.3. Although all three tariffs are rational in this setup, the distribution of the given answers differs from the expected one. It is shifted in favor of the handset subsidy tariff.

Applying chi-square goodness of fit tests[9], 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. In contrast, for 70 min. and 120 min., the null hypothesis that each option is chosen equally often can not 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, but with increasing tariff cost, even more participants tend to prefer the option with a handset subsidy, yielding lower down payments.

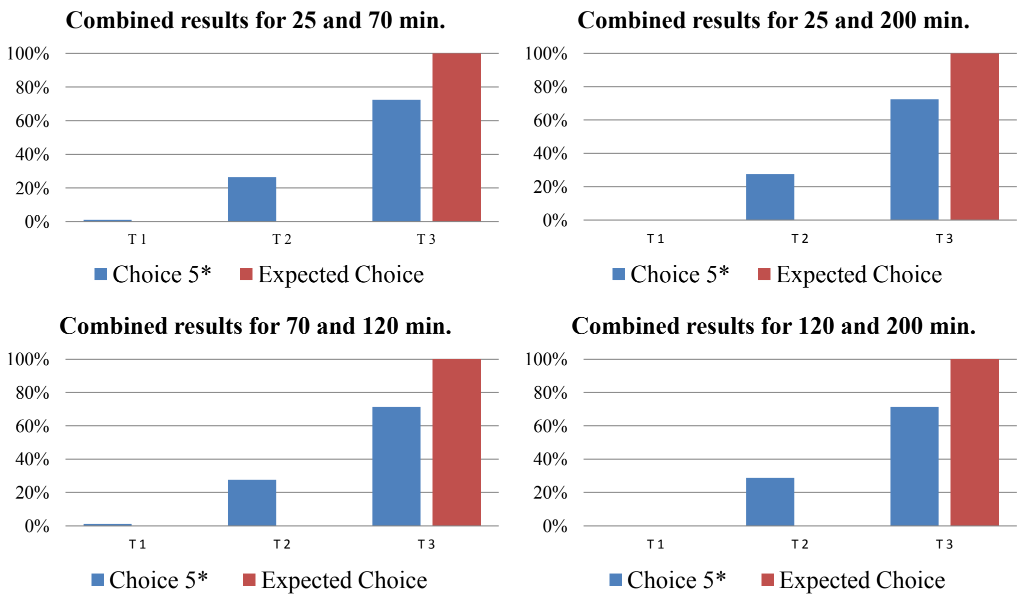
In question 5^* we have introduced higher costs for the hire-purchase option in comparison to the buy now option. Additionally, we have rearranged the tariff choices to avoid habituation effects. Participants can choose between a tariff with a handset subsidy (T1), a hire-purchase option with a positive mark-up (T2) and a buy now option (T3). The buy now option dominates in all usage groups. Figure 5.4 illustrates our results. We find that in all possible usage combinations about 30% of the participants prefer the hire-purchase option over the direct purchase, even if they incur a 1% loss due to higher costs. Applying once more chi-square goodness of fit tests for all usage combinations, we find that in all cases the observed choices are significantly different from the expected ones, all on a 5% significance level or higher.

Compared to the results of question 3^* for 25 min. and 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

[9] A chi-square goodness of fit test tests whether observed percentages for a categorical variable are significantly different from expected percentages. For further information see Büning/Trenkler, 1994.

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 occurred losses in question 5^* do not prevent them from choosing this option. Summing it up: Consumers are biased in favor of the handset subsidy and the hire-purchase option but only up to an individual limit. If costs for the preferred option exceed this certain threshold, consumers select the cost-minimizing tariff.

Figure 5.4: Choice 5* - Realized Choices differ from Expected Choices



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 section 5.4.2, 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.

5.4.2 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 expensive. 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 5.3, 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. All 76 observations are independent as we merge only the results of different usage levels performed by 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 ($mob_{int,high}$), 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 5.2[10]. As we drop all irrational choices, our observations reduce to 76. 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 5.2 for the probit regression, we can directly interpret these effects: The probability of selecting the hire-purchase option is 0.20 higher if a subject is $female$. Additionally, the probability of choosing T3 increases by 0.20, 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

[10] A detailed description of all relevant variables can be found in table 5.5 in the appendix.

Table 5.2: 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)
$mob_{int,high}$	-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	76	76
$PseudoR^2$	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

of selecting the hire-purchase option is reduced by 0.23. Our results are robust applying logit regression. Around 13.5% of the total variation is explained by our model. A drawback is that all three variables are only significant at a 10% 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 3 that the variation between the three tariff options is low due to identical costs.

In addition, we examine choice 5*, where we have included a make-up of about 1% 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 85 observations are independent as we merge only the results of different usage levels performed by different participants. Table 5.3 summarizes our empirical results for the representative 25 min. and 200 min. usage.[11]

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% significance level or higher. The probability of selecting the direct purchase option decreases by 0.02 per year of age. Being an E-net customer reduces the likelihood of choosing T3 by 0.24. The reason might be that price-sensitive 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 with 0.00 rather small. Being satisfied with their mobile operator increases the probability of selecting T3 by 0.35. Moreover, 28.4% of the total variation is explained by our model. All aspects considered, the findings suggest that some individual factors shape mobile phone tariff choice.

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

[11] The probit estimations for all other possible usage combinations can be found in table 5.6 in the appendix.

Table 5.3: 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)
$mob_{int,high}$	-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	85	85
$PseudoR^2$	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

5.5 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 started to 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 mobile 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.

Being confronted with mobile 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 mobile phone bills. However, in reality mobile 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 innumerably many tariffs. Additionally, the number of relevant parameters is typically not limited to three. This makes it a lot more difficult for consumers to select 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.

Besides, consumers seem 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-purchases of mobile devices. In one of our setups, about 10% select the cost-dominated handset subsidy, indicating a strong bias. And among the two rational payment options for the handset (direct purchase and the hire-purchase), participants clearly prefer the second possibility.

These findings are also confirmed in a second setup, where around 28% 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 mobile operators, as they can easily profit from consumers preferences. In fact, operators seem to exploit existing biases. For example, T-Mobile and Vodafone continue to subsidize mobile devices, whereas o2 offers the direct purchase or the hire-purchase of the iPhone. Within o2 tariffs, the hire-purchase option includes no interest payments compared to the direct purchase (o2, 2010; T-Mobile, 2010; Vodafone, 2010). However, it is also possible to buy the iPhone directly via the Apple store where it is up to 8% less expensive compared to the o2 offers. This induces that o2 introduces hidden interest rates for the hire-purchase option. Still, consumers could prefer purchasing via the operators. Transaction costs might be one explanation, biased preferences for hire-purchases as we found it 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. Especially, 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[12]

Welcome to this decision experiment regarding mobile 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 mobile 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 mobile 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

[12] 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 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%.
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 mobile 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[13]

Welcome to this decision experiment regarding mobile phone tariffs

Please indicate your average mobile 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 mobile phone 25 minutes a month. The following tariffs apply to the identical mobile phone of company X. Decisions 1 - 5 are independent of each other. Please choose exactly one tariff.

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

[13] 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 handset: = 0 talers, monthly subscription fee = 10 talers, price per minute for outgoing calls = 0.3 talers.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

T3: Price for the handset: = 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 mobile phone of company X. Decisions 6 - 10 are independent of each other. Please choose exactly one tariff.

Your mobile phone invoice:

- Invoice date 10/2010
- Billing Increment 60/60
- Mobile 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 mobile phone tariffs.

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

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

T3: Price for the handset: = 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 mobile phone tariffs.

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

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

T3: Price for the handset: = 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 mobile phone tariffs.

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

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

T3: Price for the handset: = 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 mobile phone tariffs.

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

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

T3: Price for the handset: = 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 mobile phone tariffs.

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

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

T3: Price for the handset: = 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 5.4: 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	0.57	0.50	0	1
less pleased	87	0.15	0.36	0	1
discontent	87	0.05	0.21	0	1

Table 5.5: 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
$mob_{int,high}$	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 5.6: 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)
$mob_{int,high}$	-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	85	85	85	85
$PseudoR^2$	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 5.7: 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 6

Conclusion

The following chapter, Chapter 6, summarizes the central findings and discusses further research directions.

Part 1 of the present thesis deals with fixed-mobile substitution on both the access and the traffic level. Chapter 2, entitled **Does the Growth of Mobile Markets Cause the Demise of Fixed Networks? Evidence from the European Union** and coauthored with Ulrich Heimeshoff, analyzes fixed-mobile access substitution in the European Union. Therefore, we use the numbers of fixed and mobile subscriptions in each country and estimate effects of price changes of the respectively other product on fixed and mobile subscription rates. Other factors, especially economic and technical indicators, are also controlled for. Studying 27 EU countries from 2003 to 2009, we find evidence for substitutability of fixed and mobile services, but have some problems of endogeneity in our econometric model, which are solved by instrumenting prices with termination rates. In detail: the magnitude of the cross-price elasticity of the lagged fixed-line price on the mobile subscription level found is +0.19 (significant on a 5% level), indicating that a 1% increase in the lagged fixed-line price would lead to a 0.19% increase in the current mobile subscription rate. In contrast, the cross-price elasticity of the mobile price on the fixed-line subscription remains insignificant. Different specification tests indicate the validity of our specifications. Therefore, we conclude that we only find one-way-substitution on the access level, as cellular phones usually cannot be substituted completely by fixed-line devices. Additionally, the estimated degree of substitutability from fixed towards mobile services is in range with previous empirical findings. However, comparisons should be carried out with caution because other papers use different datasets and estimation methods.

Chapter 3, entitled **What is the Magnitude of Fixed-Mobile Call Substitution? Empirical Evidence from 16 European Countries** and coauthored with Ulrich Heimeshoff, empirically analyzes the substitutional relationship between fixed and mobile services on the traffic level. Therefore, we calculate short- and long-run (cross-price) elasticities between the national outgoing fixed-line traffic and the prices of telecommunication usage, e.g. the prices of fixed-line and mobile calls, by applying dynamic panel models. Other factors, especially economic and technical indicators, are also controlled for, e.g. the number of mobile-only and prepaid customers, penetration rates, demographics and the GDP. Possible endogeneity problems in our econometric model are solved by instrumenting prices and penetration rates with own lags and a set of different termination rates. We create a unique panel data set which contains information on 16 mainly Western European countries for the time period from 2004 to mid-2010, on a quarterly basis. We find the own-price elasticities of the fixed-line price on the fixed-line traffic volume to be in a range between -0.14 and -0.17 in the short run, and between -0.47 and -0.49 in the long run. The magnitudes of the cross-price elasticities of the mobile price on the fixed-line traffic volume are lower, within the range of +0.13 in the short run and between +0.37 and +0.43 in the long run. All elasticities found are statistically significant on a 5% significance level and diverge from other related research analyzing cross-price elasticities for fixed-line call demand. As we have found modest one-way substitution from fixed to mobile services on the access level, our results focusing on the traffic level indicate much stronger substitution effects towards mobile telecommunication networks. Therefore, our findings have a strong impact with regard to regulation. Although we show that fixed and mobile markets are converging and becoming closer substitutes, regulatory obligations in the two markets are still quite different. In conjunction with the estimation results the suitability of the definition of separate fixed and mobile markets in the current European regulatory framework may need to be reconsidered for future telecommunications regulation.

In the present thesis, the analysis focuses on the substitutability between fixed and mobile voice services. However, as mobile broadband is prevailing, future research should therefore further investigate the substitutability between fixed and mobile broadband services.

Chapter 4, entitled **Analyzing Competitive Effects of Exclusively Dealt iPhones in European Mobile Markets**, deals with the introduction of the iPhone and its innovative distribution. We have looked at the downstream retail market and analyzed the effects of holding an exclusive iPhones dealership on operators' performance. We find that throughout the period of the exclusivity arrangement, privileged operators generated on average about 1.2 percent higher monthly revenue per subscriber compared to their competitors, who were unable to offer the iPhone. Taking the average number of subscribers into account, this amounts to an about 31.2 million USD PPP higher annual profit for operators offering iPhones. To sum up, in line with the theoretical literature, we find that asymmetric exclusivity arrangements lead to higher profits for privileged firms compared to their competitors. Although we cannot directly observe the strategy of Apple, the large increase in Apple's revenue gives at least some evidence for the economic theory indicating that the manufacturer Apple has also profited from its exclusive dealing strategy. Due to our data structure, we are unable to give advice concerning welfare issues. Therefore, further research should focus on the effects the iPhone exclusivity had on welfare.

Chapter 5, entitled **Irrationality Rings! - Experimental Evidence on Mobile Tariff Choices** and coauthored with Julia Graf, examines how consumers decide between mobile phone tariffs with different contract components and why irrational choices may occur. Therefore, we run an experiment with 87 members of the Heinrich-Heine University and test for preferences in selecting mobile phone contracts. Abstracting from demand uncertainty and preferences regarding service quality, images of operators and network externalities, our focus lies on the choice between contracts with handset subsidies, direct purchase or deferred payments of the mobile device. From our experiment we infer that participants are often not aware of their actual consumption and, in line with the findings on flat-rate biases, respondents systematically overestimate their usage. Additionally, the experiment shows that participants are generally able and willing to detect optimal tariffs. Furthermore, with increasing usage level, consumers' performance improves. However, some participants hold strong preferences for certain tariff forms, seducing them to choose cost-dominated offers. In our setup, we find that respondents prefer tariffs involving subsidies or hire-purchase options for handsets over contracts including the direct purchase of the device.

Chapter 5 has merely presented a first step in the investigation of consumers' preferences for different handset payment forms. Further work should especially consider potential biases from increasing tariff complexity and the effects of network externalities.

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Düsseldorf, den 03.05.2013

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