Are Consumers Myopic? Evidence from Handset and Mobile Services Choices*

Ambre Nicolle†

This version: October 2023.
Revised version coming soon

Abstract

In this paper, I estimate discrete choice models for handsets and mobile tariffs using a sample of 10,738 subscribers of a European mobile telecommunications operator observed between April 2011 and December 2014. The estimates are used to compute a measure for consumers' valuation of future costs, which captures how they trade off current and future expenses when making their choices, which can be interpreted as their level of myopia. I show that, overall, consumers undervalue future costs, with some heterogeneity across groups of consumers, and more importantly, over time, as consumers' myopia reduces over the period studied. This evolution is related to structural changes in the market, namely the entry of a new competitor and the introduction of tariffs that are not bundled with phones, which impacted prices and the variety of options offered by firms, as well as consumers' awareness regarding the total costs implied by such choices. Finally, I estimate a series of counterfactuals to assess the gain in consumers' welfare resulting from the market changes. The results suggest consumer welfare gains were driven by the overall price decline subsequent to the entry of the new competitor, but also, and more importantly, by the introduction of a new form of tariff which increased price transparency for consumers.

*I acknowledge funding from the European Union's Framework Programme for Research and Innovation Horizon 2020 (2014-2020) under the Marie Sklodowska-Curie Grant Agreement No. 754388 and from LMU Munich's Institutional Strategy LMUexcellent within the framework of the German Excellence Initiative (No. ZUK22). I am grateful to Marc Bourreau, Gregory Crawford, Toker Doganoglu, Ralf Elsas, Christos Genakos, Lukasz Grzybowski, Tobias Kretschmer, Ulrich Laitenberger, Thierry Pénard, Helena Perrone, Yutec Sun, Frank Verboven and Christine Zulehner for their useful comments and suggestions. I also thank participants at various seminars. All errors are mine.

†ISTO, LMU School of Management, University of Munich, Germany. E-mail: a.nicolle@lmu.de

1 Introduction

Consumers facing a choice that involves an intertemporal dimension may undervalue or, conversely, overvalue future costs and benefits from a decision. Undervaluation of future costs has been documented in choices of air conditioners (Hausman, 1979), heating systems (Dubin and Mc Fadden, 1984), cars (Dreyfus and Viscusi, 1995; Busse et al., 2013; Allcott and Wozny, 2014; Grigolon et al., 2018) and more recently for photovoltaic systems (De Groote and Verboven, 2019). Assessing the magnitude of such implicit discount rates (which can be interpreted, if they are too high, as consumer myopia) is crucial to understand better how consumers make consumption choices, but also to help decision-makers design policies that ensure consumer protection or design programs to promote the adoption of a new (durable) technology.

Although mobile tariffs typically tie consumers to a provider over an extended period of time and include a mobile handset at a one-off price, intertemporal choices in the mobile telecommunications market have been scarcely studied. Typically, consumers have the choice between several options regarding handsets, mobile service attributes (such as allowances of voice, sms and data), and various pricing schemes. The latter were differentiated by the amount of upfront payments (paid by the consumer at subscription) and subsequent recurrent ones, paid over the duration of the contract. The introduction of SIM-only tariffs, i.e. mobile plans which are not bundled with handsets, in recent years, expanded the choice set considered by individuals but, more importantly, increased transparency with regard to the trade-off between current and future expenses. In this paper, I document this trade-off and highlight how it differs across individuals and over time. To do so, I develop a discrete choice model of demand for handsets and mobile tariffs. I use a unique dataset of 10,738 subscribers to a European telecommunications operator who selected a handset and a tariff between April 2011 and December 2014. Consumers can either choose a contract with a subsidized handset which involves a low upfront price for the handset but a higher monthly recurring charge in the future, or choose a SIM-only contract, which is typically cheaper and purchase their handset at full price, from any vendor.

I use estimates from the demand model to compute a measure of consumers' valuation of future costs, which can be interpreted as the degree to which consumers are myopic (or forward-

looking) when making their decision. Estimation results suggest that, on average, consumers undervalue the future costs, but heterogeneously so. For example, I find that there are significant differences across age groups, but not between genders. Estimation results also suggest that the undervaluation of future costs significantly decreased over time, along with the adoption of SIM-only tariffs. Even though the natural interpretation of this result is that the increasing number of SIM-only subscribers mechanically drove the level of valuation of future expenses up, I argue that this can be linked, more generally, to changes in prices and variety of tariffs subsequent for the entry of a new mobile network operator in the market I study. Indeed, I show that all consumers tend to have less undervaluation of future costs after this entry, including those who selected SIM-only tariffs as well as consumers who selected tariffs with handsets. I finally conduct a counterfactual analysis to assess the welfare gains of changes observed in this market. I show that, more than the price decline, the introduction of sim-only tariffs is the major driver of welfare gains that can be assessed over the period.

This paper contributes to a better understanding of consumers' intertemporal preferences and makes three important contributions. First, it is one of the few papers that explore the question of time discounting using individual-level data. It allows highlighting and quantifying heterogeneity across individuals, based on several observed socio-demographic variables. Second, it is the only paper, to my knowledge, which aims at quantifying such phenomenon in the mobile telecommunication markets, which have been pointed out as being particularly sensitive in terms of consumer detriment (European Commission, 2017). Finally, because I observe several cohorts of subscribers entering the market at different points in time, I can assess the evolution of myopia and how the competitive environment likely influenced it. In particular, my findings suggest that changes in the competitive landscape of an industry can yield important consumer welfare gains through declining prices, but also through increased transparency and variety of products, which can, as in this specific setting, allow them to make choices that appear to be less myopic.

The findings are relevant for economic policy as they link competition dynamics to firms' behavior, which in turn affects consumers' decision-making. They are also relevant for firms' strategies as they highlight how the industry reacted to the introduction of what can be in-

terpreted as a disruptive business model - and how this triggered important changes in how individuals select products, with a potential impact on their satisfaction and loyalty.

The remainder of the paper is organized as follows. Section 2 covers the related literature. Section 3 describes the industry and its recent evolution. Section 4 provides a description of the data. Section 5 specifies the model. Section 6 discusses the empirical results and provides an overview of the robustness tests conducted. Finally, Section 7 concludes.

2 Related Literature

This paper contributes to the literature on consumers' intertemporal choices, i.e. choices that involve a trade-off between costs and benefits at different points in time. Such decisions are faced, for example, by firms that select which investments to make, or consumers who decide to save, lend or spend money. In this paper, I adopt a static setting to analyze the intertemporal choices of consumers who make a choice at time t, given available products and current prices.[1]

The theory of discounted utility is the most widely used framework for analyzing intertemporal choices (Ericson and Laibson, 2019). It highlights the existence of a parameter (the *discount factor*) that impacts the utility derived from future expenses or earnings flows. Evidence of undervaluation of future expenses has been documented in various markets, but predominantly in energy markets where consumers face a trade-off between capital cost and operating costs. Hausman (1979) computes an implicit discount rate for air conditioners purchase and finds an average rate of 20%, decreasing with the household's income level. This suggests that consumers are biased toward the present. Dubin and McFadden (1984) use a similar approach for the choice of heating and cooling systems and found similar values. More recent empirical work distinguishes the market interest rate from consumers' subjective valuation of the future, often named *attention weight*, and interpreted as a measure of consumer myopia. Such attention weights have

[1]The empirical analysis presented in this paper is conditional on the fact that individuals already decided to subscribe to a mobile contract so that dynamics elements are not crucial. However, in other settings implying durable good adoption or replacement, dynamic aspects could be of importance as prices typically decline and quality improves, suggesting that modeling dynamics and the option to wait are required. This has been studied in the economic and marketing literature, both from the methodological standpoint (e.g. Dubé et al., 2014; Bronnenberg et al., 2008) and in more applied settings (e.g. digital camcorders in Gowrisankaran and Rysman, 2012; photovoltaic systems in De Groote and Verboven, 2019; and books in Daljord, 2022).

also been measured in the car market in the US (Busse et al., 2013; Allcott and Wozny, 2014) and in Europe (Grigolon et al., 2018). These studies share a similar conclusion: undervaluation of future costs (sometimes referred to as consumer myopia) estimated in these markets exists but is modest. Using a dynamic approach, De Groote and Verboven (2019) measure consumers' undervaluation in the adoption of photovoltaic systems. They find that households significantly discount the future and that this led the subsidization program implemented by the government (based on future production subsidies) to be more expensive than what it could have been with an alternative policy based on an upfront investment subsidy. This piece of evidence highlights the role that consumers' valuation of future expenses can play in the efficiency of policies. In the same fashion, Grigolon et al. (2018) find that, despite consumers' undervaluation of future fuel costs, fuel taxes are more effective than taxes on less fuel-efficient cars, because of consumer mileage heterogeneity. In addition to its impact on the efficiency of policies, consumers' valuation of future expenses, or myopia, affects more generally the functioning of markets. It can play a role in the competition between firms (Gabaix and Laibson, 2006) and was listed as one of the sources of consumer detriment by the European Commission (see for example the reports published in 2007 and 2017). There is also a significant body of literature in marketing and strategy on consumers' intertemporal choices. A large number of papers have shown that individuals are biased towards the present (Zauberman, 2003; O'Donoghue and Rabin, 1999; Thaler, 1981). The reasons explaining this undervaluation of future outcomes have been often attributed to the perception of these outcomes at different points in time (Loewenstein, 1996; Zauberman and Lynch, 2005) or to the perception of the time horizon (Zauberman et al., 2009). Also, Loewenstein (1988) demonstrates, using experiments, how framing, in the sense of Kahneman and Tversky (1979), can play a role in an intertemporal setting.[2]

This paper adds to the literature on consumer intertemporal choices in documenting consumers' valuation of future expenses in an economically important market in which it has been very scarcely studied, i.e. the mobile telecommunications market.[3] This market has two addi-

[2]See the survey of literature by Soman et al. (2005) for additional discussion on the reasons for present bias of individuals. See also Loewenstein and Thaler (1989) who discuss several "anomalies" which can be observed in intertemporal choices.

[3]According to IDC (2022), the worldwide telecoms services' revenue reached 1.6 trillion USD in 2021, with about 50% of revenue generated with mobile services.

tional interesting features: (i) consumers make choices on a time horizon that is significantly shorter than the time horizon taken into account by individuals buying a car or investing in a photo-voltaic panel, (ii) it has been pointed out as particularly prone to consumer detriment by the European Commission (2017).

Measuring the undervaluation of future costs in the mobile telecommunications market also contributes to the understanding of consumer behavior in such industries. There is an extensive strand of literature documenting tariff choices and tariff-choice biases (Ben-Akiva et al., 1987; Lambrecht and Skiera, 2006; Lambrecht et al., 2007), price elasticities (Pereira and Ribeiro, 2011) and willingness to pay for service attributes (Rosston et al., 2010; Grzybowski and Liang, 2015). Dynamics of tariff choices have also been documented through empirical work on switching costs (Grzybowski, 2008) but also on consumers' learning (Miravete, 2003), Genakos et al., 2019). Literature on handset choices is less abundant, although it covers a wide range of issues, from documenting switching costs between phones (Park and Koo, 2016) or between brands and OS (Grzybowski and Nicolle, 2021), to estimating patent value (Hiller et al., 2018). Papers relying on the simultaneous choice of mobile service and handset are scarce and focus on estimating switching costs between service providers (Cullen and Scherbakov, 2010), measuring network effects between operating systems (Liu and Luo, 2022), or commenting on the impact of exclusivities between smartphone manufacturers and mobile operators (Sinkinson, 2014).

Finally, this paper relates to the large body of literature on the impact of competition on mobile services prices and variety (e.g. Genakos, et al., 2018; Bourreau et al., 2021). In particular, Bourreau et al. (2021) suggest that the entry of a new operator in the French market benefited consumers through an increased variety of tariffs, itself related to the introduction of *fighting brands*. Although their data document the demand for all operators and includes both post-paid and pre-paid tariffs, it is aggregated at the geographical-area level. Moreover, it includes no information on handsets selected by consumers. In contrast, the data I use in this paper are at the individual level and contain extensive information on available and selected tariffs and handsets, which allows to provide complementary insights on the impact of a similar structural change (i.e. the entry of a new competitor) on consumers' valuation of future expenses.

In this paper, I combine elements of the intertemporal choice literature with elements related to competition in mobile markets. Extending the approach by Allcott and Wozny (2014), I allow the measure of consumers' valuation of future costs to vary across individuals and over time. I link its development over time with the evolution of tariff prices and variety, themselves triggered by structural changes taking place in the market.

3 Industry Background

Mobile handsets have been, since the early stage of the industry, bundled with mobile tariffs involving a long-term commitment for the consumer, generally 24 months. This bundling strategy, which typically implies a *handset subsidy*, has been widely used by mobile operators to facilitate the take-up of mobile services (Barros, 2006; Tallberg et al., 2007) but also as a competitive tool for firms (Choi et al., 2001).[4] SIM-only tariffs, i.e. mobile plans which are not associated with any handset, and therefore which do not include any handset subsidy, were introduced by operators in response to competitive pressure from a new entrant (as in the United Kingdom or France), to cut down operational costs (as in Spain) or to serve niche segments such as commitment-averse or highly price sensitive consumers.[5] These tariffs also allow for a wider choice set in terms of handsets. Indeed, consumers may be willing to acquire handsets manufactured by marginal brands which were traditionally not included in the operators' catalogs, or be willing to purchase a refurbished or second-hand phone. Moreover, handsets purchased directly from the manufacturers' shops such as Apple or Samsung stores often come with additional services which can be highly valued by consumers. The emergence of SIM-only tariffs led to the development of alternative financing schemes for handsets such as installment plans, interest-free credit offered by operators, and leasing deals. Some market analysts also argued that the introduction of these tariffs affected the replacement cycle of handsets. While the handset replacement cycle of handsets was following closely the commitment period associated with mobile tariffs in a large number of countries, it tended to lengthen since 2013, which coincides with

[4] A good description of these practices across countries and over time is given in OECD (2013).

[5] See the report from the market research firm Wirelessprofit (2015).

the decline of mass handset subsidization.[6] Finally, regulation of mobile services also played a role in the changes observed in the market. Apart from bans on handset subsidies in Belgium (1991-2010), Finland (1996-2006), and Korea (2000-2006), policymakers aimed to reduce consumer lock-in by imposing a regulatory framework on the early-contract fees or contract length. Some national regulators also encouraged -or imposed to- operators to unbundle services and handsets or to provide more transparent information in displaying separate payments for service and repayment of the handset (OECD, 2013).

In the market I study, SIM-only tariffs were introduced during the period of time my data cover, allowing to compare consumers' choices, as well as prices and variety of products, before and after. Additionally, the data covers the commercial launch of 4G services by the four main operators, i.e. the Mobile Network Operators (MNOs).[7] Figure A.1 gives an overview of the changes which occurred over the period 2009-2014. The major event which occurred over the period is the entry of a new mobile operator in January 2012. In its application for the license, the entrant announced it will exclusively offer SIM-only tariffs at very attractive prices. This was anticipated by its competitors, which therefore simultaneously launched their low-cost subsidiaries in October 2011. Even though a few sim-only tariffs were available before this date, it marked the beginning of their popularity.

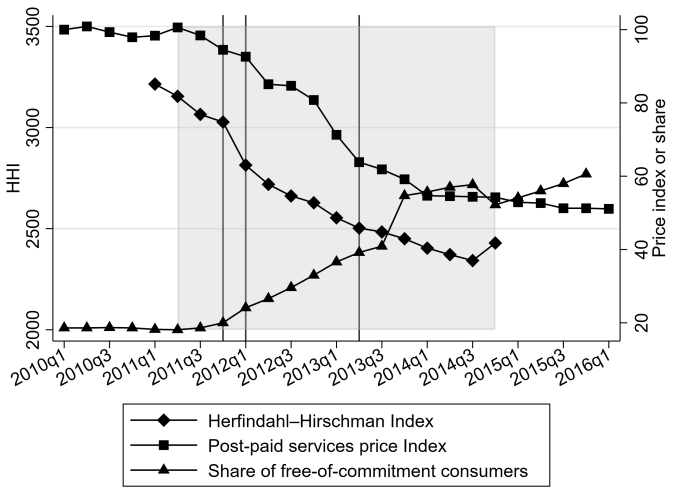
Figure 1 shows the evolution of three key elements at the market level. First, it presents the evolution of the Herfindahl-Hirschman Index[8] which captures the level of concentration in the market. Second, it shows the evolution of the price index for post-paid mobile services in the country. Finally, it shows the evolution of the share of free-of-commitment consumers, which is the indicator used by the national regulator to comment on the fluidity of the market. The free-of-commitment consumers are defined as consumers who subscribed to a contract that is currently finished or consumers who do not have a contract - typically the SIM-only subscribers. One can observe that prices and the HHI both sharply decreased over the period, with a price

[6] See the report `International Comparisons: the Handset Replacement Cycle` by Recon Analytics and `http://reconanalytics.com/2015/02/2014-us-mobile-phone-sales-fall-by-15-and-handset-replacement-cycle-lengthens-to-historic-high/`

[7] 4G licenses were attributed in December 2011 and January 2012.

[8] The HHI is computed in summing the squared quarterly market shares of each MNOs. This computation excludes the Mobile Virtual Network Operators (MVNOs).

Figure 1: HHI, Price Index and Share of free-of-commitment consumers



Note: The grey area corresponds to the time period covered by the data used in this paper. **Source**: Own computation based on data from the National Regulator and Yankee Group.

index that declined from about 100 at the beginning of 2011 to about 55 at the end of 2014 where it stabilized,[9] and an HHI that declined from 3,200 at the beginning of 2011 to 2,400 at the end of 2014.[10] We also observe the take-off of the share of free-of-commitment consumers, which is mostly driven by the increasing number of SIM-only subscribers after the third quarter of 2011.[11]

4 Data

The data set consists of a sample of 10,738 new subscribers to a European operator, observed between April 2011 and December 2014. The original sample consists of a panel of 118,231 consumers with post-paid contracts from which 20,614 new subscribers are initially extracted. The data include information on the subscriber (age, gender, municipality of residence), the

[9]The base 100 is for January 2010.

[10]The HHI value theoretically ranges from close to zero (perfect competition) to 10,000 (monopoly), if one uses market shares ranging from 0 to 100.

[11]Unfortunately, the number of SIM-only subscribers is not available at the country level. In the next section, I provide some statistics on the share of consumers they represent in my sample.

identifier of the tariff selected as well as the brand and model of handset used. Because this paper focuses on the first choice of these consumers, I keep only the first observation of each individual so that the data set becomes a cross-section. After restricting the sample to individuals aged between 18 and 100 years old, it consists of 20,277 observations. Also, I drop 12 subscribers for whom I do not have information on the municipality of residence. Using the postcode of individuals, I complement the dataset with publicly-available information on median income, the density of population and unemployment rate at the city level. Next, I merge the tariff identifier available in the data with the list of tariff characteristics provided by the operator. This catalog includes information on voice and data allowance, as well as contract length and a dummy for the handset subsidy option. I have to drop a few tariffs for which no information is available. After this operation, the sample consists of 19,222 individuals.

Thereafter, I merge handsets observed in the data with a list of quarterly prices. About half of them were provided by the operator, while the other half was collected via web-scraping[12] or purchased from International Data Company. I was able to merge 80.8% of the sample and keep 15,540 observations. To compute the exact amount of handset subsidy obtained by each consumer, I use an additional catalog provided by the operator. The amount of subsidy may vary across models and over time, which is recorded in this catalog. Unsurprisingly, the more expensive the tariff, the bigger the subsidy.[13] I drop from the sample consumers who selected a tariff that includes a handset subsidy but for which no list price is available. I lose a non-negligible number of individuals in the sample through this step but it is necessary to ensure that the prices introduced in the demand model are correct. Finally, I merge the handsets with a list of characteristics scraped from GSMarena.com. It provides public information about the characteristics of handsets, i.e. dimensions, operating system, battery life, year of release, etc.[14]

[12]For handsets that were not sold by the operator, I collected the prices at release from an independent website that aggregates characteristics and prices of handsets. I consider these prices reasonable for the six months following the release date. After this period, I consider the price of a given handset as missing.

[13]For example, in December 2014, Apple's iPhone 4S was sold at 492€ with a SIM-only contract, 370€ with a tariff above 20€ per month, 340€ with a tariff above 30€, 239€ with a tariff above 43€, 99€ with a tariff above 55€ and 49.9€ with a tariff above 90€.

[14]I have compared characteristics of consumers in the final sample with consumers from the original sample, which is assumed unbiased, and found no significant differences. Also, prices and types of tariffs offered by the operator are not significantly different from its competitors, if we exclude the new entrant. See the statistics presented in the last section of Appendix C, in the online appendix.

Table 1: Summary Statistics (Sample of 10,738 consumers, 2011-2014)

Variable	Mean	Std. Dev.	Min.	Max.
Age of the subscriber (in years)	42.99	15.15	18	100
Female (0/1)	0.51	0.5	0	1
Tariff price (in Euros)	34.41	20.6	4.9	169
Handset list price (in Euros)	359.53	176.83	16	769.9
Tariff with handset (0/1)	0.84	0.37	0	1
Amount of handset subsidy (in Euros)	188.09	123.28	0	588
Contract length (in months)	20.53	7.42	0	24
Unlimited calls (0/1)	0.26	0.44	0	1
Call allowance (in minutes)	78.98	71.22	0	360
Data allowance (in GB)	0.87	1.3	0	10
Fixed broadband option (0/1)	0.15	0.36	0	1
iPhone user (0/1)	0.25	0.43	0	1
Voice consumption (in minutes)	83.56	254.26	0	11691.07
Data consumption (in GB)	0.23	0.79	0	18.79
N		10,738		

The final sample consists then of 10,738 individuals.

Table 1 provides an overview of the main variables included in the dataset. The average consumer is 43 years old. 51% of consumers are women. The average price of a tariff is 34€ and the average list price of a handset is about 360€. A very large part of chosen tariffs consists of mobile plans with handset subsidy (84%), with an average amount of subsidy of 189€. The average commitment period is about 20.5 months, due to the high share of consumers choosing the standard 24 months contract. 26% of the tariffs selected offer unlimited calls and the average call allowance is of 79 minutes. The attribute "Data" is never offered as an unlimited option: it ranges from 0 and 10 GB, with an average allowance of 0.87 GB. In terms of actual usage, individuals in the sample consume, on average, 84 minutes of calls and about 0.23 GB per month.

Table B.1 (in the online appendix) shows the evolution of tariffs selected by new consumers over time. The average price of a tariff declined by 12% between 2011 and 2014.[15] The average list price of handsets declines with a similar magnitude (14%), from 378€ to 323€. The amount of subsidy granted to consumers who selected a traditional tariff with a handset decreases by almost 30%. This reduction may be surprising at first glance as one would expect subsidies

[15]National price index for mobile tariffs shows a decrease of 38% between April 2011 and December 2014.

to go up in the context of increasingly sophisticated handsets, and consequently increasingly expensive handsets. Two opposite trends are reflected in this figure: on the one hand, in the context of increased competitive pressure, operators need to compete for premium consumers, namely those who are willing to pay for a high-end tariff associated with a high-end smartphone. This would imply a higher amount of subsidy. On the other hand, prices of tariffs with handset subsidy also declined: since subsidies are computed on ranges of tariff prices, it mechanically declines too. Results from a regression of the handset subsidies, presented in the online appendix C (Table C.4), show that they decreased over the period, all other things being equal.[16]

A sharp take-up of SIM-only contracts is observed between 2011 and 2014. It goes from a market share of 3.5% in 2011 to 34% in 2014, peaking in 2013 with almost 35% of subscribers in the sample. The upfront price of handsets for these consumers decreased by almost 40% between 2011 and 2014, suggesting that they tend to choose cheaper devices when facing their full cost at purchase. Over the same time period, an increasing popularity of tariffs with no commitment or short commitment period (12 months) is observed: the share of no-commitment contracts is multiplied by 20, while short-term contracts more than doubled between 2011 and 2014. The increasing popularity of tariffs with no commitment is almost exclusively driven by the demand for tariffs offered by low-cost brands, introduced in October 2011.[17] Table B.1 (in the online appendix) also shows shares of observations by year. The significant drop observed between 2011 and 2014 is due to the extraction method used by the operator to construct the raw dataset. I show in Appendix C that it does not exist significant differences between the consumers observed at each period (See Table C.1).[18]

Table B.2 (in the online appendix) presents shares of handset brands over time. Four brands of handsets are the most widespread in the sample: Apple, Samsung, Nokia, and BlackBerry.

[16] I have run several OLS regressions for the amount of subsidy and included month dummies as explanatory variables. Plotting these month dummies (as shown in Figure C.2) shows that the amount of subsidies had the tendency to decline over the period, in particular since 2013.

[17] These brands offer a simplified range of SIM-only contracts with online subscription and online customer service. They represent 98% of free-of-commitment subscribers in the sample.

[18] Individuals are selected among all customers of the firm based on their date of birth (day and month only). Over time, individuals churn but their phone numbers are potentially reallocated to other consumers so that new consumers are observed in the sample. The high share of observations for 2012 corresponds to a period of net gain of consumers, mainly driven by the take-off of low-cost tariffs. The extraction method does not yield any selection bias since the construction process of the raw data was based on consumers' attributes which are unrelated to the variables of interest.

These market shares are relatively stable over time, except for Blackberry, which represented 17.4% of selected handsets in the sample in 2011 and only 1.4% in 2014. The market share of other brands was multiplied by 10 between 2011 and 2014. Generally, the penetration of SIM-only tariffs enabled marginal, less-known, brands - until then excluded from the mainstream retailing scheme - to gain market shares. Additional descriptive statistics are presented in Appendix C.

As a first step to analyze the intertemporal choices of consumers, it is important to describe the total costs involved in these choices and highlight how they differ across the traditional tariffs and the newly introduced SIM-only tariffs. Figure B.1 (in the online appendix) shows a histogram of the present value of total costs[19] of selected combinations of tariffs and handsets over 24 months, which was the standard contract length during the observation period. The combinations with SIM-only tariffs cost on average 790€ over 24 months, ranging from 132€ to 2656€. The combinations which involve a handset subsidy cost tend to be more expensive, with an average cost of 983€, ranging from 273€ to 4047€. Although informative, observing the average total costs for the two types of combinations does not allow to comment precisely on the differences in total costs that can be observed for a given combination, i.e. with the same handset and similar services. To measure the difference in costs related to the choice of one option compared to the other (traditional tariffs or SIM-only), I match each tariff with a "twin tariff" which includes exactly the same allowances and options[20], but differs in the dimension "SIM-only or not". This process is successful for 364 tariffs out of 518.[21] Then, for each consumer in the sample, I compare the total cost charged with her chosen tariff and the matched tariff. Here, again, I use the present value of future costs, using an interest rate of about 6% per year. This is possible for 4,680 consumers out of 10,738. Differences are presented in Figure B.2, in the online appendix. One can see that SIM-only tariffs are not always the cheapest option, as negative values indicate that the SIM-only alternatives may be more expensive than their traditional counterparts, up to 470€ over 24 months. Additionally, we observe that the

[19] I use an interest rate that varies with the month of the subscription and is, on average, of 6.03% per year

[20] It also involves the same commitment period: 12 or 24 months.

[21] In some cases, I cannot identify an equivalent tariff. It is important to note that the matching process excludes SIM-only contracts with no commitment period. Indeed, it is not possible to find a twin tariff for these contracts as a handset subsidy is never offered by the operator if the consumer is not committed for at least 12 months.

alternatives involving a subsidy can generate an additional cost for the subscriber up to 478€ over 24 months. Overall, the differences computed for this sample reveal that the average difference of total cost is about -75€ (with a standard deviation of 127.8), meaning that combinations that involve a handset subsidy have the tendency to be cheaper, on average, than their SIM-only counterparts. In percent, this translates to SIM-only combinations being on average 9.2% more expensive over the period.[22] Although counter-intuitive at first glance, this observation is in line with the findings from the OECD report (2013).[23] This illustrates that there is no dominant type of contract, as one type of choice (SIM-only tariff combined with stand-alone handset vs. bundle of tariff and handset) is not *per se* the best (cheapest) option for consumers.

5 Econometric Model

A discrete choice framework The model developed in this paper relies on the assumption that consumers subscribe to a tariff and purchase a handset simultaneously, though not necessarily as a bundle.[24] Therefore, the price paid for the handset equals the list price of the device if the selected tariff is a SIM-only tariff, and the discounted price (i.e. list price minus the subsidy) if the tariff is a traditional tariff. This constitutes the upfront payment at subscription time. The recurring charge, which is equal to the price of the tariff, is paid every month, until the end of the contract. Over the life of the contract, the sum of these charges represents what is called in this paper the *future costs*.

A discrete choice model framework is commonly used to analyze the choices of telecommu-

[22]This computation is based on a reduced sample which excludes, by design the low-cost tariffs - therefore this number has to be interpreted with caution.

[23]The report highlights that, even though tariffs with handsets generally represent a higher total cost for consumers, it also happens that the choice of tariffs combined with handsets is "more economically rational than the independent acquisition of handsets". They argue that such a situation can be observed in very competitive markets and that the coexistence of SIM-only tariffs and competitively-priced tariffs with handsets give the best options to consumers.

[24]I can observe which handset is used at subscription time thanks to the device's International Mobile Equipment Identity (IMEI), registered in the operator's information system. I do not have information about when the handset was actually purchased and no information about the price actually paid by the consumer to acquire the handset. Nevertheless, for consumers who subscribed to a tariff with handset subsidy (84% of observations in the sample), timing and price are correct as, by design, the handset is obtained at the subscription, at a price that depends on the chosen tariff and advertised in the operator's catalog. For the SIM-only consumers, there is no way to be sure the handset was purchased at the time of subscription; consequently, I drop SIM-only consumers using handsets that are not available on the market anymore, obviously not purchased new at consumer's subscription.

nication products. These models allow analyzing situations where an agent (e.g. a person, a firm) faces a choice or a series of choices over time, among a set of options. Each individual chooses with preferences depending on her characteristics (e.g. age, gender) and the product attributes (e.g. price, quality of services). A rational consumer chooses the alternative which maximizes her utility. Since the data set contains alternative-specific variables, a conditional logit model is estimated. The first step of modeling is to define an exhaustive and mutually exclusive choice set. Consumers are assumed to choose a combination of tariff and handset among all the combinations available at the current month. Each combination is constructed with a tariff from the list of available tariffs and a handset from the list of available handsets at the current month.[25] Constructing an exhaustive choice set would be computationally impractical as each choice set would consist of about 70,000 alternatives and the final data set of over 752 million of observations. The number of alternatives is limited by fixing a number of tariffs and handsets randomly chosen. This is a standard approach in the discrete choice literature (see Ben-Akiva et al., 1987). Robustness and implications of this approach are discussed in Section 6.1.

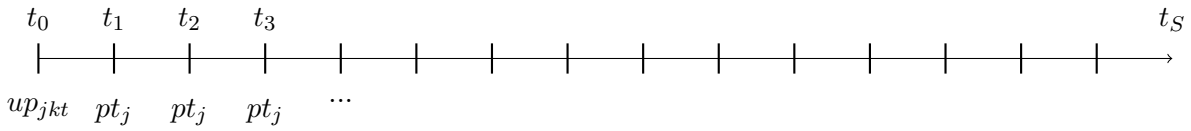
The majority of available tariffs since April 2011 are offered with several options in terms of contract length and handset subsidy. Prices differ in each of these situations. The tariff associated with the lowest recurring charge is typically the tariff with no handset subsidy. These tariffs are offered free of commitment or with a 12-months commitment period, the latter being about 5-10€ cheaper compared to the no-commitment tariff. Tariffs with handset subsidies are associated with a commitment period of 12 or 24 months whereas the 24 months contracts are usually cheaper. In the choice set, in addition to the selected tariff, 10 randomly selected tariffs are added. Each tariff appears in all its available versions (handset subsidy, SIM-only, with or without commitment). Consequently, the number of unique tariffs in the choice set varies between 11 and 54. These tariffs are combined with the selected handset, as well as with 10 random handsets. Handsets that are not listed in the operator's catalog only appear combined

[25]Most of these handsets are listed in the operator's catalog. In this case, I use the list price from this catalog. In reality, handsets may be purchased elsewhere but their prices are assumed equal to the operator's list price. For handsets outside of the operator's list, I use the official public price when released in the national market or data provided by IDC.

with SIM-only tariffs in choice sets. Each choice set consists of between 209 and 550 alternatives per individual.[26] This variation is related to the difference in the number of options available for a given tariff.

An intertemporal decision Let us consider a consumer i selecting a tariff j and a handset k, at month t. The consumer's decision affects her intertemporal budget constraint in two ways: on the one hand, the consumer faces the upfront cost up_{jkt} at t_0, i.e. at the time she subscribes, and on the other hand, she pays the recurring charge pt_j from t_1 to t_S, i.e. over the life of the contract, denoted S. Figure 2 illustrates this intertemporal decision.

Figure 2: Time horizon of a consumer decision



The upfront cost of the handset up_{jkt} equals the list price of the handset if a SIM-only tariff is chosen, or the list price reduced by the subsidy of the operator if a traditional tariff is chosen. It naturally varies across tariffs j, handsets k, and time t. The recurring charge pt_j only varies across tariffs j. Future costs considered by consumers when they make their choices have to be computed as the present value of the future recurring charges.[27]. To compute the latter, I use the computation detailed in Grigolon et al. (2018).

$$PT_{jt} = \frac{pt_j}{(1+r_t)^1} + \frac{pt_j}{(1+r_t)^2} + ... + \frac{pt_j}{(1+r_t)^{S_{ij}}} = \frac{1}{r_t}[1-(1+r_t)^{-S_j}]pt_j$$

where PT_{jt} denotes the present value of future costs for a tariff j selected at time t, pt_j denotes the price of the tariff j, S_j is the time horizon of the choice which varies over tariffs j and r_t which denotes the market interest rate at the time of decision t. Therefore, PT_{jt} varies across tariffs j as their monthly charge and contract length vary (impacting S), and over time t as the interest rate r also varies.

[26] All combinations of tariffs and handsets in the choice set are theoretically possible: the operator's catalog provides a level of subsidy for each handset, by ranges of tariff prices.

[27] I assume here that the amount paid by the consumer every month, the bill, is equal to the tariff price.

For r_t, I use the average consumption credit rate granted by national banks, which ranges from 5 to 6.15% per year over the period.[28] This value is very close to assumptions on r made by Allcott and Wozny (2014) and Grigolon et al. (2018) who both use $r = 6\%$ to compute the present value of future payoffs in the automobile market.[29] I convert the yearly rate into a monthly rate as the time periods I consider are months. Alternative assumptions on r are considered in Section 6.1.

For S_j, which represents the time horizon consumers consider when they trade off present and future costs, I use the commitment period associated with the tariff when the contract length is different from zero. When the contract is not associated with a commitment period, which is the case for a large part of the SIM-only tariffs, I assume S_j to be equal to 19 months, which is the average time a non-committed consumer keeps her tariff in the data.[30] I consider alternative values for S in Section 6.1.

A standard linear utility specification is used for individuals $i = 1, ..., N$ over different tariffs $j = 1, ..., J$ and handsets $k = 1, ..., K$. Utility depends on tariffs and handset characteristics and on the observed and unobserved individuals' characteristics. The indirect utility of individual i for tariff j and handset k, selected at time t is given by:

$$U_{ijkt} = x'_{jk}\beta - \alpha_{it}(up_{jkt} + \gamma_{it}PT_{jt}) + \hat{\xi}_j + \hat{\xi}_k + \varepsilon_{ijkt} \tag{1}$$

where x'_{jk} is a vector that includes the following variables: a categorical variable for data allowances (500 MB, 1, 2, 4 or 10 GB); a dummy for unlimited calls; a continuous variable for

[28] This information is publicly available on the website of the central bank of the country.

[29] Allcott and Wozny (2014) and Grigolon et al. (2018) use $r = 6\%$ as the market interest rate to compute the valuation of future payoffs in the automobile market. They use a weighted average of discount rates in the case of financed payments and cash payments. The value is calculated as follow:37% of the vehicles of the Allcott and Wozny's panel is financed at a real interest rate of 6.9% on average. 63% are purchased cash. In this case, the cost opportunity of funds is assumed to be equal to S&P 500 (Standard and Poor's index) returns, i.e. at the time they did the study 5.8%. The weighted average is equal to 6.2. They use 6% for more convenience.

[30] Existing literature often sets the time horizon to be equal to the expected or average life duration of the good. Indeed, in the case of heating, cooling systems, or cars, goods may be sold at any moment; no contractual relationship bounds the consumer with the retailer who sold the good. In the framework of this study, the contrary is often the case. For instance, consumers willing to switch service suppliers will be charged a (potentially very high) termination fee. However, if we consider taking a proxy that is close to the ones used in the previous papers, one might consider using the replacement cycle of handsets as the time horizon of the choice. In this case, S would take a value close to 32 months, which is the handset replacement cycle in this country, as estimated by Recon Analytics in 2012. I explore, as an alternative specification this value for S.

call allowance (in minutes) for tariffs which do not include unlimited calls; a dummy variable for fixed broadband option; a categorical variable for tariff type (which combines handset subsidy option and commitment period, ranging from 1 to 4); a dummy variable for each main brand of the sample; a dummy for smartphone; age of the handset model (in months); height, width, thickness (in mm), camera quality (in megapixels) and battery life (in hours) of the handset; a dummy variable for 4G handset when the tariff is compatible with 4G services.

up_{jkt} denotes the upfront cost of the handset and PT_{jt} denotes the present value of future costs. I interact these variables of interest (up_{jkt} and PT_{jt}) with quarters of subscription, age groups, and gender. $\hat{\xi}_j$ and $\hat{\xi}_k$ capture the unobserved tariff and handset characteristics. They are obtained from first-stage regressions that I describe next. ϵ_{ijkt} is the error term.

The vector of coefficients β captures the average valuation for handsets and tariffs characteristics. α_{it} is the marginal utility of income of an individual i[31] making a decision at time t. γ_{it} is Allcott and Wozny (2014)'s attention weight. If γ equals zero, future costs do not have any weight in the consumer's present decision: she is fully myopic. If γ equals 1, the consumer perfectly tradeoffs the initial cost of the handset against the present discounted value of future costs. If $\gamma > 1$, the consumer overvalues future costs when making her or his decision. In my model, I allow γ to vary over the quarter of subscription t and across individuals i (age groups and gender).

To measure γ_{it}, I can estimate the following equation:

$$U_{ijkt} = x'_{jkt}\beta - \alpha_{1it}(up_{jkt}) + \alpha_{2it}(PT_{jt}) + \hat{\xi}_j + \hat{\xi}_k + \epsilon_{ijkt} \tag{2}$$

where α_{1it} denotes the price coefficient for the upfront cost and α_{2it} is the price coefficient for the present value of future costs. I allow these coefficients to vary across consumers and over time of subscription. I can retrieve γ_{it} based on the equivalence of Equation 1 and Equation 2.

$$\alpha_{it} = \alpha_{1it} = \frac{\alpha_{2it}}{\gamma_{it}} \rightarrow \gamma_{it} = \frac{\alpha_{2it}}{\alpha_{1it}} \tag{3}$$

[31] In the main specification of the model, $\alpha_i t$ does not vary over each individual, but over age groups and gender.

Price endogeneity and unobserved product attributes Price may be correlated to the unobserved quality of handsets and tariffs and may be endogenous in the demand estimation. I use the control function approach as suggested by Petrin and Train (2010) which consists of a two-stage estimation.[32] In the first stage, I regress the products (handsets and tariffs) prices on various product attributes, including some which are not introduced in the consumer utility. It is reasonable to assume that these attributes impact the costs faced by firms, and consequently affect prices. These attributes are likely not taken into account by consumers when they make their choices. For the handsets regression, I add more fine-grained characteristics and interact all of them with a time trend. These interactions capture the decreasing price of technological components over time (e.g. camera, screen), observed by the operator, but unlikely observed by consumers. For the tariffs regression, I interact the data allowance and the 4G dummy with the number of active 4G antennas for this operator each month.[33] These interactions capture the increasing cost borne by the operator that is likely unobserved by consumers.

In the second step, I use the residuals from these regressions and introduce them as additional regressors in the main estimation. I show estimation results from first-stage regressions in Tables B.3 and B.4 (in the online appendix). Alternatively, I estimate a model with fixed effects for handsets and tariffs, as suggested in Berry et al. (2004) and Goolsbee and Petrin (2004)). I discuss the methodology and results in Section 6.1.

Choice Probabilities and Estimation For the sake of simplicity, I will denote n a combination of tariff j and handset k. I also omit the subscript for the time of decision t. An individual i chooses a combination n of a tariff and a handset if this maximizes her utility among all the available alternatives in her choice set. A part of this utility (V_{in}) is observable to the researcher.

$$U_{in} = V_{in} + \epsilon_{in} \tag{4}$$

[32] An example of this approach applied to smartphone choices can be found in Grzybowski and Nicolle (2021).

[33] This data is publicly available and published by the National Frequency Agency. Figure B.5 (in the online appendix) shows the evolution of the number of active antennas for 2,3 and 4G technologies.

The probability that individual i chooses a combination n is given by:

$$P_{in} = Prob(V_{in} + \epsilon_{in}) > Prob(V_{im} + \epsilon_{im}) \quad \forall m \neq n \tag{5}$$

The closed-form expression derived from the previous equation, which is the classic logit probability, is given by:

$$P_{in} = \frac{e^{V_{in}}}{\sum e^{V_{im}}} \tag{6}$$

under the assumption of the error term ϵ having a standard Type 1 extreme value distribution, with cumulative distribution function:

$$F(\epsilon_{im})) = exp^{-exp^{-\epsilon_{im}}} \tag{7}$$

This translates into the log-likelihood function:

$$\mathcal{L}_i(\theta) = \sum_n z_{in} ln(P_{in}) \tag{8}$$

Given that our data set includes information on individuals (e.g. age, usages) as well as on alternatives (tariff prices, handset price, and various quality measures), I use regressors that are alternative-specific (e.g. tariff and handset characteristics) and others which are interactions between case-specific variables (e.g. age groups, time of subscription) and alternative-specific variables. Consequently, I estimate a conditional logit model using the *clogit* command in Stata. This model fits the maximum likelihood for each group, i.e. at each consumer decision level.

Consumer Surplus In the counterfactual simulations, I calculate consumer surplus for different scenarios. I follow the approach by Train (2009):

$$E(CS_i) = \frac{1}{\alpha} ln(\sum_{k=1}^{K} \sum_{j=1}^{J} e^{V_{ijk}}) + C \tag{9}$$

where $E(CS_i)$ denotes the expected consumer surplus, α the marginal utility of income, V_{ijk} is consumer i's valuation of observable attributes of the alternative that combines a tariff i with

a handset k, and C is an unknown constant that represents the fact that the absolute level of utility cannot be measured. A change in the consumer surplus can be computed as follow:

$$\Delta E(CS_i) = \frac{1}{\alpha}[ln(\sum_{k=1}^{K^1}\sum_{j=1}^{J^1} e^{V^1_{ijk}}) - ln(\sum_{k=1}^{K^0}\sum_{j=1}^{J^0} e^{V^0_{ijk}})] \tag{10}$$

with superscripts referring to the period before (0) and after (1) the change which impacts the observed utility V_{ijk}.

6 Estimation Results

Description of the demand estimation results Table A.2 shows results from the main models. Model I shows the estimates obtained from a model which includes no interaction and no residuals from first-stage regressions. Model II includes the residuals from tariff price and handset price regressions.[34] Model III includes interactions of the price coefficients (α_1 and α_2) with time and Model IV includes interactions with time and consumers' characteristics (age and gender). I discuss the estimates obtained from Model IV as it is the most complete and preferred specification. I find highly significant and reasonable coefficients for all explanatory variables. In particular, I find, as expected, negative coefficients for the upfront cost (-0.09) and for the present value of future costs (-0.03).

Categories of data allowance are positively valuated, with coefficients ranging from 1.11 for 500 MB to 2.9 for 10 GB. Tariffs are offered with an unlimited call option or a limited call allowance, which ranges from 30 minutes to 600 minutes. The unlimited option is highly valued by consumers as compared to the base category. We also observe that each minute of allowance is positively valued by consumers. The option for fixed broadband which provides access to fixed internet and telephony at home (DSL or FTTH) is also positively valuated. Regarding the type of tariffs (with or without handset, contract length), I use as a base outcome the most common tariff type, i.e. the 24-month contract with handset subsidy. Coefficients associated with other types of tariffs are negative and significant, suggesting that consumers value the possibility to bundle

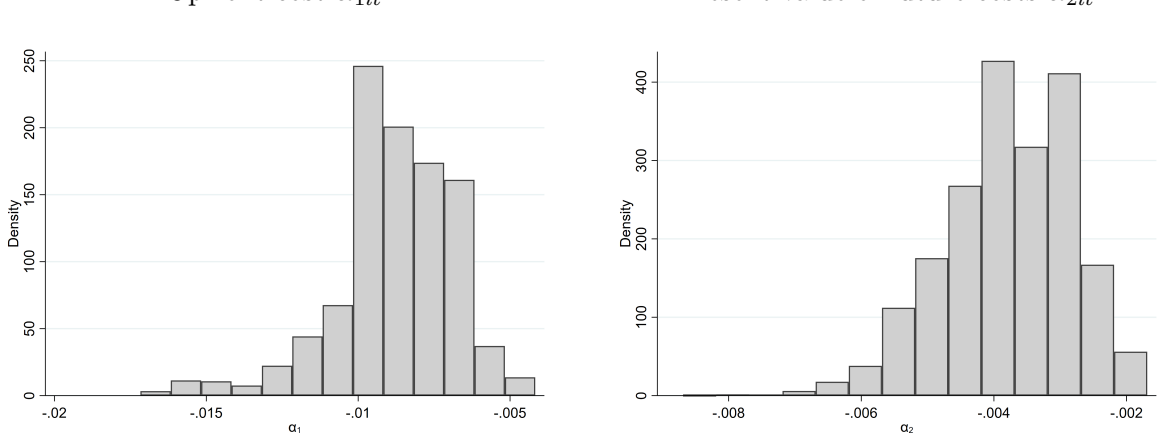
[34] Estimates from the first stage regressions are shown in Table B.3 and B.4 in the online appendix.

their mobile tariff and their handset in the framework of a long-term contract, once controlling for the monetary aspects which are captured in the price coefficients. Dummy variables for the main brands capture consumers' valuation for these brands compared to marginal ones, which constitute the base outcome. Apple and Blackberry products are particularly highly valued by consumers. The coefficient for the smartphone dummy is also positive and significant. Time since release which captures the age of the handset model is negative, meaning that on average, consumers prefer more recent models. Positive valuation for height shows consumers' preference for large screens. The positive coefficient on thickness is surprising as one could expect that consumers would not appreciate thick handsets - however, it exists some correlation between thickness and age of the model as these characteristics evolved significantly over time. Camera quality, which is measured in megapixels, and battery life, measured by the stand-by time, are both positively valued. Finally, the estimates suggest that the 4G compatibility, which captures consumers' valuation for this recent technological advance, is positively and significantly affecting utility.

To account for the endogeneity of tariff and handset price, I use the control function approach which involves a two-stage estimation, as described in Section 5. The coefficients estimated for residuals from the first-stage regressions are positive (0.06 for handsets and 0.02 for tariffs), but only significant for the former. As suggested by the changes observed between Model I and Model II, the introduction of residuals increases the upfront price coefficient in absolute terms. Thus, as the theory suggests (see Train (2009), without correcting for endogeneity this price coefficient is biased toward zero.

Price coefficients and undervaluation of future costs The estimates obtained for the interactions of α_1 and α_2 with time and consumers' characteristics are shown in Figure B.3, in the online appendix. As shown on the left side of the figure, a large number of interactions of α_1 with time are not statically significant, meaning that this price coefficient did not evolve over time. However, coefficients on the interactions with socio-demographics suggest a significant impact of age and gender. Compared to the base group (45-54 y.o.), consumers are less sensitive to the upfront cost of the handset, while this price sensitivity is growing the older consumers.

Figure 3: Price coefficients for upfront and future costs



Note: Computed for 10,738 individuals. Estimates used for the computation are from Model IV. Main results are shown in Table A.2.

We also observe that female consumers are more price sensitive. As shown on the right side of the figure, the interactions of α_2 with quarters are almost always significant, meaning that a significant evolution was observed over the period. We also observe heterogeneity across age groups and gender. Here, again, the younger consumers are less price sensitive compared to the base group, while females are more price sensitive.

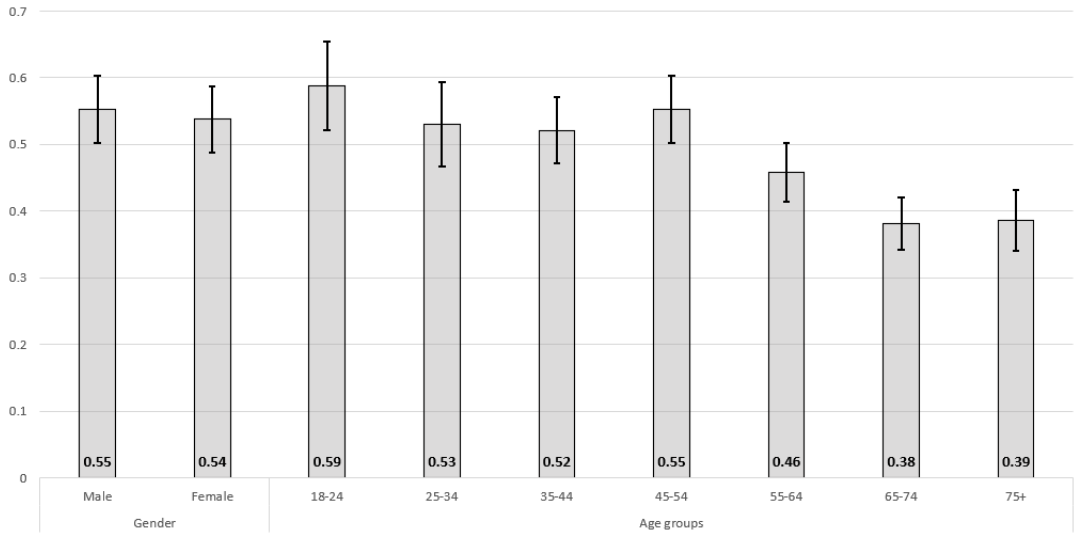
The distributions of α_{1it} and α_{2it}, obtained by combining the main price coefficients with the time and group interactions, are presented in Figure 3. The distribution of γ_{it} for the whole sample is presented in Figure B.4 in the online appendix.

Figure 6 shows how γ varies across age groups and gender, given that the base group for the quarter of subscription is Q4 2014. First, we see that the attention weight is on average slightly higher for male compared to female subscribers, but the difference is not statistically significant. Second, we observe that γ tends to decrease for age groups beyond 55 years old. I do not find statistically significant differences between groups from 18 to 54 years old.

Figure 7 presents the main result of this paper and shows the evolution of γ over time.[35] At the beginning of the time period studied, the attention weight is stable, with a value of 0.35

[35]Results for the second and third quarter of 2012 are omitted because the number of observations for these quarters is not sufficient to be reliable - standard errors are really large for the interactions with these quarters - without having an impact on the estimation results overall.

Figure 6: Heterogeneity of attention weights γ across consumers, based on observable characteristics

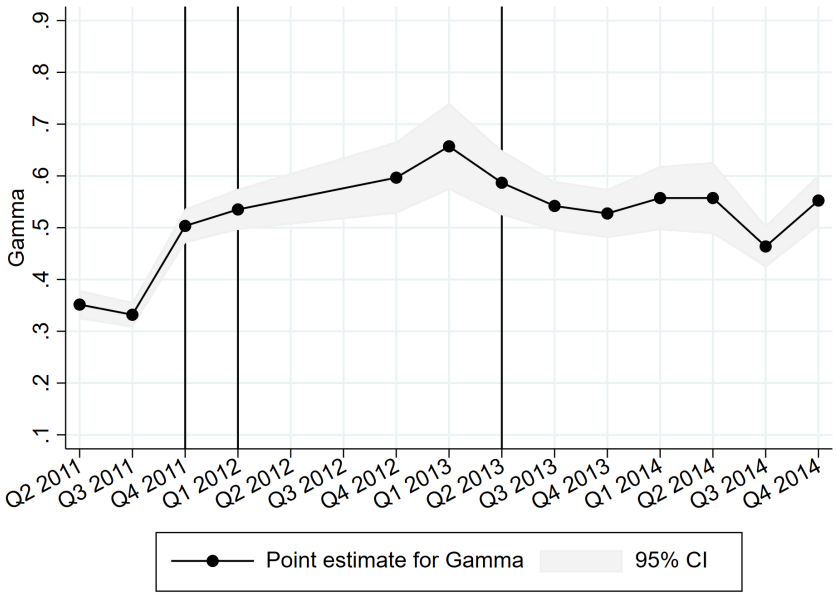


Note: Computed for Q4 2014. Confidence intervals presented correspond to 95%. Estimations results are from Model IV presented in Table A.2.

which indicates a significant level of undervaluation of future expenses. It sharply increases to 0.5 during the last quarter of 2011, which coincides with the introduction of low-cost tariffs. Subsequent to this, the attention weight keeps on increasing, reaching its peak in the first quarter of 2013, with a value of 0.65, which suggests that consumers still undervalue future expenses in a significant way, but clearly less than at the beginning of the period. Overall, the estimated attention weight increased by 62%, which translates into a decline of myopia by about 32% after the introduction of SIM-only tariffs.[36] It appears to decline again after the launch of 4G services by the operator, but in a moderate magnitude (from 0.65 to 0.59). Even though some minor variation is still observed, it appears that the attention weight is stabilizing around 0.55 from the first quarter of 2013. These values can be compared with the attention weight estimated for other markets. For example, Allcott and Wozny (2014) find an average attention weight of 0.76 for consumers choosing cars in the U.S., and Grigolon et al. (2018) an average of 0.91 for consumers choosing cars in Europe. It appears that consumers selecting a phone with mobile

[36]The average value for γ over Q2-Q3 2011 is 0.34, and 0.55 in the periods after. In the absence of myopia, the attention weight equals 1. Therefore, we can interpret the degree of myopia as $1 - \gamma$. Thus, over the two first quarters of 2011, the degree of myopia is about 0.65, and 0.44 afterward.

Figure 7: Attention weights γ over time



Note: Results are omitted for Quarters 2 and 3 of 2012. These observations are excluded because of their very small number of observations. The first vertical line corresponds to the introduction of sim-only tariffs, the second to the entry of a new MNO, and the third one to the commercial launch of 4G services. Estimations results are from Model IV presented in Table A.2.

services are much more myopic than consumers choosing a car.

Interpretation of the results The significant evolution of γ over time can be interpreted in the light of the changes which occurred in the market over the period. First, the introduction of low-cost brands in October 2011 coincides with a significant increase in the variety of tariffs available to consumers, in particular through the introduction of SIM-only tariffs. Second, the entry of a new operator in January 2012 initiated a period of intense competition as Figure 1 shows, with the declining market concentration and prices. Third, the launch of 4G services in April 2013 marks the beginning of a new technological era regarding mobile services, which offered consumers the possibility to consume much more data, under the condition that they upgrade their devices - in other words if they change their handset to a recent and potentially more sophisticated model.

Disentangling the impact of each of these events is challenging, in particular, because the

first two are intrinsically related. However, from a visual inspection of Figure 7, one can argue that the introduction of sim-only tariffs (which corresponds to the first vertical line) had a significant impact on γ, which jumps from 0.33 to 0.50. This would imply that the availability of these new tariffs results in consumers making choices that appear less myopic. The second line, which corresponds to the entry of a new MNO, increased further the average valuation of future expenses by consumers, which goes from 0.50 to 0.53. The introduction of 4G services corresponds to the beginning of a period where γ declines again, going from 0.66 in the first quarter of 2013 to 0.59 in the second quarter, and then stabilizes. This suggests that consumers subscribing to a new contract at the introduction of 4G services were, on average, more myopic compared to consumers from previous cohorts. This could be explained by their need to purchase an expensive LTE-compatible handset, but also by the operator's strategy to offer particularly attractive deals with 4G smartphones at low upfront costs.

Beyond the variety and prices of tariffs, one can suspect that consumers' attention is one additional driver of the (observed) myopia decline. One key element would support this hypothesis - and it lies in how the new entrant positioned its tariffs (a reduced range of low-cost SIM-only plans) in *opposition* to the tariffs traditionally offered by its competitors. The firm invested massively in public relations and advertising, fiercely calling attention to the fact that the handset subsidies were often hiding 'extremely high interest rates', resulting in consumers paying for their phones 'several times'.[37] Together with the media coverage of the entry itself, is very likely that consumers' attention was drawn to these questions, increasing their awareness of the total cost that their choices imply when they select a tariff and a handset, thus potentially explaining the increased valuation for future expenses.

The events observed in this market seem to be consistent with the theoretical setting developed by Gabaix and Laibson (2006). Indeed, in their model, firms are competing in a market where a share of the consumers are myopic - the *naïve*, while others are not - the *sophisticated*. These firms are selling products that come with a high-priced add-on and have to decide if they

[37]In a public announcement, the CEO of the firm declared that handset subsidies were "disguised consumer loans" with extremely high implicit interest rates reaching 300 or 400% over the life of the contract. Additionally, the new entrant sued the second largest operator for unfair competition related to its handset subsidization practice. This dispute was only concluded in March 2018 with a decision of the court in favor of the established operator.

shroud it or not. One firm may decide to behave aggressively and inform the consumers about the shrouding behavior of its competitors. In this case, it renounces the profit generated by the add-on in the hope of gaining market shares. Nevertheless, this behavior is risky and a "curse of debiasing" may arise if substitutes for the add-on exist. Sophisticated consumers may stay loyal to the incumbent firm and just avoid the add-on. In my setting, the entrant can be considered as the aggressive firm which intends to "de-bias" the myopic consumers. To do so, it draws consumers' attention to the extra cost incurred by long-term contracts involving a handset subsidy. While some consumers switch to the entrant, some others stick to the incumbent firm which reacts by offering better deals, which would be captured in this paper in the increasing γ.

An alternative interpretation of my results is that consumers are budget-constrained and that the cohorts I observe at different points in time differ in this regard. While I cannot exclude that some individuals selected a tariff with a low upfront cost not because of intertemporal preference but because of their budget constraint, it is very unlikely that they represent a large share of them. I also find no differences in socio-demographics across the different cohorts I consider, as shown in Table C.1 in the online appendix.

Counterfactual Simulations The estimates from the discrete choice model I have developed can be used for counterfactual analyses. In particular, such a model allows to compute consumer welfare, and changes in consumer welfare, if one or several of the variables impacting utility evolve. In this paper, I documented two major changes: the entry of a new operator which led to a significant price decline of the tariffs, and the introduction of SIM-only tariffs which increased the variety of products available. In a series of scenarios, I simulate the absence of one or both of these changes in the market. I use the estimates from Model IV to compute consumer welfare. I follow the standard approach described in Train (2009) and detailed in Section 5.

To implement the absence of the first change, i.e. the one leading to the price decline, I need to obtain an estimation of the prices at the pre-entry level. To obtain these prices, I estimate two hedonic price regressions, one for the SIM-only tariffs and one for the traditional tariffs, to retrieve two quality-adjusted price indices. These indices are shown in Figure B.6 (in the online appendix). I replace the prices with the pre-entry prices and recompute the probabilities

associated with the choice of each combination, for each consumer. I use these new probabilities to compute the change in consumer surplus. To implement the absence of the second change, i.e. the introduction of SIM-only tariffs, I follow Grzybowski and Liang (2015) and set the prices of sim-only tariffs at an arbitrarily extremely high price (in this case, 10,000€) so that the probability that these tariffs are chosen is equal to zero, which is equivalent to withdrawing them from the choice sets. Probabilities are then "reallocated" to the available traditional tariffs.

I consider four scenarios that combine one or several changes described above. They are compared to the baseline scenario, which corresponds to the situation with observed prices and observed choice sets. The first scenario simulates a situation where all tariffs are available and only the sim-only segment witnesses a price decline. This scenario would correspond to the situation where the increased competitive pressure that follows the entry only affects the sim-only segment while the established operators maintain their prices on the classic tariffs segment. Second, I simulate a situation where all tariffs are available but their prices are at the pre-entry level. This scenario would correspond to a situation where the new MNO would introduce the sim-only tariffs but without being aggressive in its pricing strategy. Third, I simulate a situation in which sim-only tariffs would not be available, with prices of tariffs and handsets remaining unchanged. This scenario would correspond to a situation of increased competition on the classic tariffs segment, for example, related to the competition for 4G. Finally, I simulate a similar situation where the sim-only tariffs are not available and the prices are at the pre-entry level.

Table A.1 details the results from the counterfactuals.[38] The absence of the price decline observed on the segment of tariffs with handsets would lead to a loss of 6.6€ in consumer welfare. Absent the price decline on all tariffs, this loss would be 9.2€. More interestingly, without sim-only tariffs, consumer surplus would decline by 23€. If this unavailability of sim-only tariffs is combined with prices not declining in 2012, the loss in consumer surplus would be 33€. These numbers have to be interpreted in the light of the timing considered by the consumers at the moment of their choice, which is typically two years, even though we discussed earlier that

[38] I present distributions of the change in consumer surplus for the different scenarios in Figure B.7 in the online appendix.

some consumers are only committed for 12 months or not committed at all. Therefore, these welfare gains have to be interpreted over the duration of their contract or relationship with the operator. A back-of-the-envelope calculation enables to illustrate the economic significance of this number. For a country like the United Kingdom, one can estimate the number of consumers who subscribe to a new contract to be about 6 million every year over the focal period (2012-2014).[39] Multiplying this number with the average consumer surplus gain from the counterfactuals, we obtain a gain, at the market level, of 138 million€ per year, adding up to 414 million€ over the period 2012-2014.[40]

Overall, results from these counterfactuals highlight that, even though the price decline observed in this market contributed to the gains in consumer welfare estimated, the introduction of sim-only is the major driving force behind it.

6.1 Additional analyses and robustness checks

In this section, I present the results of additional analyses and robustness tests.

Additional socio-demographics and consumers usages Thanks to the postcode of individuals, I can merge additional information at the city level: population density, median fiscal income, and unemployment rate.[41] I interact these variables with the price coefficients. I also add interactions with voice and data usage. Results are presented in Table B.5 in the online appendix. One can observe that the density of the city of residence and the intensity of data usage decreases the sensitivity to the upfront cost. Also, the intensity of usages of voice and data both increase the coefficient on the present value of future costs. These results suggest that additional heterogeneity may be observed at the consumer level, in particular regarding usage.

[39] Here, we focus on the periods after the entry. Over 2012-2014, the country counted between 43.54 to 49.34 million post-paid subscribers (OFCOM, 2012 and 2014). Genakos et al. (2019) reported a share of switchers from 12 to 14% over the period 2010 to 2012, which probably stayed stable over the two next years (2013 and 2014). For the sake of simplicity, let us consider 46 million subscribers among which 13% select a new contract every year. This gives an average of 6 million consumers subscribing to a new contract every year between 2012 and 2014.

[40] If each consumer surplus benefits from a surplus of 23€ when they subscribe to a new contract (compared to the baseline situation without the introduction of SIM-only tariffs), the total gain, for one year, is 138 million€, what represents 414 million over the three years post-entry.

[41] This information is available on the National Institute of Statistics's website.

However, the evolution of γ is similar to what we obtain in the main specification.

Alternative interest rate and time horizon The computation of the present value of future costs relies on several assumptions regarding the market interest rate r and the time horizon S.

In the baseline computation, r equals the average rate of consumption credit granted by banks and is about 6% per year. However, as discussed in Grigolon et al. (2018), r may take the value of the opportunity cost of funds, and, in this case, the interest rate for short-term bank deposits (regulated by the State) may be considered. It varies from 1 to 2.25%. The market interest rate r could also take the value of the consumption credit rate granted by specialized companies which offer revolving credit. This rate ranges between 12.8 and 15.2%. I compute again PT_{jkt} based on a low r and a high r and estimate Model IV again. I present the results in Table B.6 and Figure B.8 in the online appendix. The impact on γ and its evolution over time are negligible.

In the baseline computation, S may take three different values, varying across tariffs: S=19 for non-committed subscribers, S=12 for 12-month contract subscribers, and S=24 for 24-month contract subscribers. In alternative estimations, I compute again the present value of future costs in imposing S to be equal to 12, 24, and 32 months for all consumers. I present the estimates I obtain in Table B.7 and the corresponding γ in Figure B.9, in the online appendix. The latter suggests that the time horizon taken into account by individuals is affecting the future attention measure γ in a significant way. Under the assumption that $S = 12$, we see that it ranges from 0.92 at the beginning of 2011 to about 1.15 in the first quarter of 2013, meaning that consumers would actually overvalue the future when trading off present and future expenses. This scenario is not plausible as it would imply that all individuals from the sample expect to stick to their contract for 12 months and then switch or churn. However, a large majority of consumers are committed 24 months to the operator and cannot easily switch tariffs.[42] The results from the alternative computation considering all consumers are trading-off for 24 months are really close to the baseline estimation, in particular for 2011 because the majority of consumers were actually

[42]The fee paid by consumers who churn before the end of their contract is regulated by national law since 2008. Switching may be possible before the end of the commitment period but the "rules" are decided by each operator and are not transparent to the consumers.

committed for 24 months at this time. In this case, the attention weight would range between 0.46 and 0.67. The last assumption for S, 32 months, would correspond to the scenario where the time horizon of the trade-off corresponds to the expected life of the handset. In this case, values for γ are significantly reduced, from 0.34 in 2011 to 0.55 by the end of 2014.

Alternative samples Because the measure of γ is significantly correlated with the share of SIM-only subscribers (correlation = 0.62), one might wonder if the increase in consumers' valuation of future expenses is fully driven by the increasing number of consumers choosing SIM-only in the data. To shed light on this issue, I estimate two alternative models on sub-samples of individuals. First, I restrict the sample to consumers who selected a contract involving a commitment period of 12 or 24 months, which can be either a SIM-only or a classic tariff with handset subsidy. They represent 9,786 individuals out of the 10 738 individuals in the original sample. Computation of γ for this sub-sample is of interest because it allows to consider a well-defined time horizon for the trade-off and to relax the assumption of S being 19 months for a part of consumers for which this information is not available, namely the non-committed consumers. Second, I restrict the sample to consumers who choose a contract with a handset subsidy. The sub-sample consists of 8 974 individuals who selected a handset in the operator's catalog and are committed for 12 or 24 months. This analysis also allows to relax the S-assumption for not-committed consumers and to see how the valuation of future costs of these consumers specifically evolved. Values for γ based on these alternative estimations are shown in Figure B.10 (in the online appendix). First, one can observe that our measure of consumers' valuation of future costs is, on average, lower for individuals who are committed or who select a tariff with handset subsidy. Second, a significant increase of γ over time is also observed in the two alternative cases. While the results obtained on the main sample suggest that γ was multiplied by 1.6 between 2011 and 2014, it was roughly multiplied by 1.5 for consumers who selected a contract with commitment and for consumers who selected a tariff with handset subsidy. This suggests that the increase in consumers' valuation of future expenses is not solely driven by the increasing number of SIM-only subscribers in the sample, as the phenomenon is still observed once they are excluded from the analysis. It also supports the hypothesis that the market changes are

responsible for the increasing valuation of future by consumers, in particular for consumers who selected tariffs associated with handset subsidies.

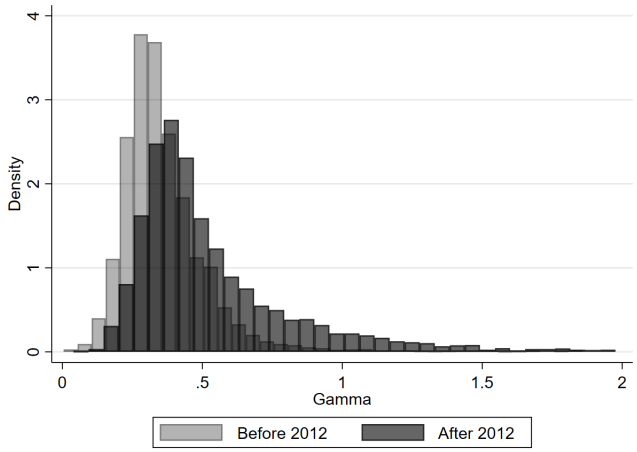
Separate regressions for quarters and years In the telecommunications industry, the characteristics of the products are evolving relatively fast. As a consequence, consumers' valuation for these characteristics might also vary over time. In my main specification, I assume the homogeneity of these valuations over time. I relax this assumption with regressions at the year or quarter level. Results for regressions at the year level are shown in Table B.8 in the online appendix. Figures presenting the evolution of γ based on the estimates for years are shown in Figure B.11 and for quarters in Figure B.12 (both in the online appendix). Both support qualitatively the robustness of my results, i.e. γ significantly increases over the time period.

Endogeneity: the fixed effects approach An alternative way of dealing with the price endogeneity issue is to use a large number of product fixed effects, as well as fixed effects interacted with time, as discussed in Section 5. Due to the very large number of products, estimating a coefficient for each tariff and handset is challenging, in particular because some products are only selected a few times. Therefore, I introduce 200 tariffs and 200 handset fixed effects, as well as handset brand interactions with time. The latter allows accounting for the evolution of the quality of brands over time. I present estimation results obtained in introducing sets of fixed effects step by step in Table B.9 in the online appendix.

Table B.10 in the online appendix allows to compare the estimates from the main specification, i.e. the one relying on the control function approach, with the estimates obtained with the fixed effects approach. One can observe that the main price coefficients are very stable. However, when comparing the γ evolution presented in Figure B.13 in the online appendix, we observe that its magnitude is reduced with the fixed effect approach, even though the trend observed is the same.

Random coefficient approach The main model, estimated with a conditional logit, exhibits the standard limitation of logit models which impose a proportional substitution across alter-

Figure 8: Distribution of gamma computed with random coefficients



natives that could result in unrealistic substitution patterns. A mixed logit specification allows to relax this assumption.

Also, even though the logit specification allows to capture systematic taste variation (in the model related to the age and gender of individuals), it does not allow random taste variation, which a mixed logit allows (Train, 2009). Therefore, as a robustness test, I estimate the main model by adding random coefficients[43] on the two key variables - namely the present value of future costs and the upfront cost of the handset, which allow additional individual taste heterogeneity. The results are presented in Table B.11 (in the online appendix) and highlight the stability of the coefficients obtained. While I do not find any heterogeneity (due to random taste variation) across consumers regarding the upfront cost, I find some for the present value of future costs, as suggested by the significant standard deviation presented at the bottom of the table. This can also be seen in Figure B.14 (in the online appendix) which presents the distribution of random coefficients I obtain.[44] Figure B.15 (in the online appendix) presents the resulting distribution of γ, and Figure 8 shows how the distribution of γ evolved before and after 2012. We observe that the distribution shifts towards higher values for γ, suggesting that the level of myopia associated with observed choices decreased after the introduction of sim-only

[43] I use 100 Halton draws.

[44] Individual coefficients for γ are obtained in using the individual coefficients for $\alpha_1 i$ and α_2 (which capture random taste variation), combined with the coefficients for interactions with age, gender, and month of subscription, which capture systematic taste variation.

tariffs.

Choice set construction Because of the large number of possible alternatives faced by consumers, one needs to randomize the combinations of tariffs and handsets included in individuals' choice sets. I evaluate the sensitivity of the results in increasing the size of the choice sets - while reducing the size of the sample to keep the size of the dataset reasonable. The results are presented in Table B.12 (in the online appendix). We observe that the results are stable and only differ marginally from what we obtain in the main specification if we exclude the full choice set scenario which is only estimated with 250 consumers. Figure B.18, in the online appendix, shows that the estimations for γ are not statistically different from each other, supporting the very marginal impact of choice set construction, except for the case with the full choice set. Given the very small number of individuals included in this regression (250 consumers), these estimates have to be considered with extreme caution.

7 Conclusion

In this article, I study consumer intertemporal choices in a market of economic importance, which has been pointed out as being prone to consumer detriment (European Commission, 2017). To do so, I study the decision of 10,738 consumers choosing a mobile tariff and a handset between 2011 and 2014. I estimate various discrete choice models and use the estimates to compute a measure of consumers' undervaluation of future costs, which can be interpreted as the degree to which consumers are myopic. Estimation results suggest that consumers undervalue future payments, but heterogeneously so. While women do not significantly differ from men in this regard, individuals from different age groups do, with the oldest individuals exhibiting the highest degree of myopia. My results also suggest that the level of consumers' undervaluation significantly declined over the period I study by about 32%, which is arguably explained by important structural changes occurring in the market. The entry of a new competitor came hand-in-hand with the introduction of a new type of contract (SIM-only tariffs), triggering a general price decline and an increase in the variety of products offered. I find that this event

generally reduced myopia, not just for the consumers who selected a SIM-only contract, but also for those who chose a tariff with handset. I finally conduct counterfactual analyses to estimate the welfare gains related to the disruption observed in this industry. For example, I show that the introduction of SIM-only tariffs increased the average consumer's surplus by 23€- what would represent an overall welfare effect of 138 million€ per year for a country like the United Kingdom, based on a back-of-the-envelope calculation.

This study makes three important contributions. First, it is one of the few papers that explore consumers' undervaluation of future costs using individual-level data. It allows highlighting and quantifying heterogeneity across individuals, based on several observed socio-demographic variables. Second, it is the only paper, to my knowledge, which aims at quantifying such phenomenon in the mobile telecommunication markets, which have been pointed out as being particularly sensitive in terms of consumer detriment. Finally, because I observe several cohorts of subscribers entering the market at different points in time, I can describe the evolution of myopia and assess how the competitive environment likely influenced it. Although this paper cannot shed light on all the complex mechanisms at play in these markets, it provides novel and robust insights into how consumers make consumption choices in a setting where the products are complex given their multiple attributes, and involve an intertemporal trade-off. Estimating the extent of consumers' time preferences is crucial to help decision-makers design appropriate policies, as highlighted in the recent example of a subsidization program for photovoltaic systems (see De Groote and Verboven, 2019).

Regarding the implications of my findings for firms' performance, they remain ambiguous as several forces are at play. First, the decline of consumer myopia decreases firms' abilities to extract rents. Also, handset subsidization has been described as a way to stimulate the adoption of new technologies, with a positive impact on the revenue of firms (for example, consumption of mobile data). A decrease in consumers' myopia would therefore impact negatively the penetration of tariffs with handsets, which can harm the adoption of newer technologies. Both aspects would ultimately reduce service providers' profitability. However, if consumers are myopic, it means that the upfront cost of handsets particularly matters for their decision-making. There-

fore, operators need to finance handsets upfront, which represents large amounts, in particular for smartphones. Without competition on handset subsidies, firms do not have to engage in these risky investments, which may improve their profitability. In addition to representing a financial burden for firms, this might limit competition as it excludes smaller operators which cannot bear this burden (Kim et al., 2004). Some firms might benefit from this new business opportunity. Finally, less myopic consumers might enter the relationship with their service provider on "better grounds", thereby fostering loyalty. Indeed, even though subsidies have been described as sources of consumer lock-in (OECD, 2013), they might also pressure consumers to "hunt" for the best deals. Without this pressure, consumers might turn out to be more satisfied with their provider, enhancing their loyalty in the long run.

References

Allcott, H. and Wozny, N. (2014). Gasoline Prices, Fuel Economy, and the Energy Paradox. *Review of Economics and Statistics*, 96(5):779–795.

Barros, P. (2006). Handset subsidies: an empirical investigation. *Working Paper*. Universidade Nova de Lisboa Seminarios Anacom.

Ben-Akiva, M., Train, K., and McFadden, D. (1987). The Demand for Local Telephone Service: A Fully Discrete Model of Residential Calling Patterns and Service Choices. *RAND Journal of Economics*, 18(1):109–123.

Berry, S., Levinsohn, J. and Pakes, A. (2004). Differentiated products demand systems from a combination of micro and macro data: The new car market. *Journal of political Economy*, 112(1), pp.68-105.

Bourreau, M., Sun, Y., and Verboven, F. (2021). Market entry, fighting brands, and tacit collusion: Evidence from the French mobile telecommunications market. *American Economic Review*, 111(11), 3459-99.

Bronnenberg, B.J., Dubé, J.P., Mela, C.F., Albuquerque, P., Erdem, T., Gordon, B., Hanssens, D., Hitsch, G., Hong, H. and Sun, B., (2008). Measuring long-run marketing effects and their implications for long-run marketing decisions. *Marketing Letters*, 19(3), 367-382.

Busse, M.R., Knittel, C.R. and Zettelmeyer, F. (2013). Are consumers myopic? Evidence from new and used car purchases. *American Economic Review*, 103(1), pp.220-56.

Choi, S.-K., Lee, M.-H., and Chung, G.-H. (2001). Competition in Korean Mobile Telecommunications Market: Business Strategy and Regulatory Environment. *Telecommunications Policy*, 25(1-2):125–138.

Cullen, J. and Shcherbakov, O. (2010). Measuring consumer switching costs in the wireless industry. *Working Paper*.

Daljord, Ø. (2022). Durable Goods Adoption and the Consumer Discount Factor: A Case Study of the Norwegian Book Market. *Management Science*, 68(9), 6783-6796.

De Groote, O. and Verboven, F. (2019). Subsidies and time discounting in new technology adoption: Evidence from solar photovoltaic systems. *American Economic Review*, 109(6), pp.2137-72.

Dreyfus, M.K. and Viscusi, W.K. (1995). Rates of time preference and consumer valuations of automobile safety and fuel efficiency. *The Journal of Law and Economics*, 38(1), pp.79-105.

Dubé, J. P., Hitsch, G. J., and Jindal, P. (2014). The joint identification of utility and discount functions from stated choice data: An application to durable goods adoption. *Quantitative Marketing and Economics*, 12(4), 331-377.

Dubin, J. A. and McFadden, D. L. (1984). An econometric analysis of residential electric appliance holdings and consumption. *Econometrica*, 52(2):345–362.

Ericson, K.M. and Laibson, D. (2019). Intertemporal choice in Handbook of Behavioral Economics -Applications and Foundations 1. Elsevier.

European Commission (2007). An Analysis of the Issue of Consumer Detriment and the Most Appropriate Methodologies to Estimate It. *Technical report*, Europe Economics for European Commission.

European Commission (2017). Study on measuring consumer detriment in the European Union. *Technical report*, Civic Consulting for European Commission.

Gabaix, X. and Laibson, D. (2006). Shrouded Attributes, Consumer Myopia, and Information Suppression in Competitive Markets. *The Quarterly Journal of Economics*, 121(2):505–40.

Genakos, C., Valletti, T. and Verboven, F. (2018). Evaluating market consolidation in mobile communications. *Economic Policy*, 33(93), pp.45-100.

Genakos, C., Roumanias, C. and Valletti, T. (2019). Is having an expert "friend" enough? An analysis of consumer switching behaviour in mobile telephony. *Cambridge Judge Business*

School Working Paper.

Goolsbee, A. and Petrin, A. (2004). The consumer gains from direct broadcast satellites and the competition with cable TV. *Econometrica*, 72(2), pp.351-381.

Gowrisankaran, G., and Rysman, M. (2012). Dynamics of consumer demand for new durable goods. *Journal of political Economy*, 120(6), 1173-1219.

Grigolon, L., Reynaert, M., and Verboven, F. (2018). Consumer valuation of fuel costs and the effectiveness of tax policy: Evidence from the european car market. *American Economic Journal: Economic Policy*, 10(3), pp.193-225.

Grzybowski, L. (2008). Estimating switching costs in mobile telephony in the UK. *Journal of Industry, Competition and Trade*, 8(2), 113-132.

Grzybowski, L. and Liang, J. (2015). Estimating Demand for Fixed-Mobile Bundles and Switching Costs Between Tariffs. *Information Economics and Policy*, 33:1 – 10.

Grzybowski, L., and Nicolle, A. (2021). Estimating Consumer Inertia in Repeated Choices of Smartphones. The Journal of Industrial Economics, 69(1), 33-82.

Hausman, J. A. (1979). Individual Discount Rates and the Purchase and Utilization of Energy-Using Durables. *Bell Journal of Economics*, 10(1):33–54.

Hiller, R.S., Savage, S.J. and Waldman, D.M. (2018). Using aggregate market data to estimate patent value: An application to United States smartphones 2010 to 2015. *International Journal of Industrial Organization*, 60, pp.1-31.

Kahneman, D., and Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, 47(2), 263-292.

Kim, H.-j., Byun, S.-k., and Park, M.-c. (2004). Mobile Handset Subsidy Policy in Korea: Historical Analysis and Evaluation. *Telecommunications Policy*, 28(1):23–42.

Lambrecht, A., and Skiera, B. (2006). Paying too much and being happy about it: Existence, causes, and consequences of tariff-choice biases. *Journal of Marketing Research*, 43(2), 212-223.

Lambrecht, A., Seim, K., and Skiera, B. (2007). Does uncertainty matter? Consumer behavior under three-part tariffs. *Marketing Science*, 26(5), 698-710.

Loewenstein, G. F. (1988). Frames of mind in intertemporal choice. *Management Science*, 34(2), 200-214.

Loewenstein, G., and Thaler, R. H. (1989). Anomalies: intertemporal choice. *Journal of Economic perspectives*, 3(4), 181-193.

Loewenstein, G. (1996). Out of control: Visceral influences on behavior. *Organizational behavior and human decision processes*, 65(3), 272-292.

Liu, Y., and Luo, R. (2022). Network Effects and Multinetwork Sellers' Dynamic Pricing in the US Smartphone Market. *Management Science*.

Miravete, E. J. (2003). Choosing the Wrong Calling Plan? Ignorance and Learning. *American Economic Review*, 93(1):297–310.

O'Donoghue, T., and Rabin, M. (1999). Doing it now or later. *American economic review*, 89(1), 103-124.

OECD (2013). Mobile Handset Acquisition Models, OECD Digital Economy Papers, No. 224, OECD Publishing, Paris.

Park, Y. and Koo, Y. (2016). An empirical analysis of switching cost in the smartphone market in South Korea. *Telecommunications policy*, 40(4), pp.307-318.

Pereira, P. and Ribeiro, T. (2011). The impact on broadband access to the Internet of the dual ownership of telephone and cable networks. *International Journal of Industrial Organization*, 29(2), pp.283-293.

Petrin, A. and Train, K. (2010). A control function approach to endogeneity in consumer choice models. *Journal of marketing research*, 47(1), pp.3-13.

Rosston, G.L., Savage, S.J. and Waldman, D.M. (2010). Household demand for broadband Internet in 2010. *The BE Journal of Economic Analysis & Policy*, 10(1).

Sinkinson, M. (2014) Pricing and Entry Incentives with Exclusive Contracts: Evidence from Smartphones. *Working Paper*.

Soman, D., Ainslie, G., Frederick, S., Li, X., Lynch, J., Moreau, P., Mitchell, A., Read, D., Sawyer, A., Trope, Y. and Wertenbroch, K., (2005). The psychology of intertemporal discounting: Why are distant events valued differently from proximal ones? *Marketing Letters*, 16(3), 347-360.

Tallberg, M., Hämmäinen, H., Töyli, J., Kamppari, S. and Kivi, A. (2007). Impacts of handset bundling on mobile data usage: The case of Finland. *Telecommunications Policy*, 31(10-11), pp.648-659.

Thaler, R. (1981). Some empirical evidence on dynamic inconsistency. *Economics letters*, 8(3), 201-207.

Train, K.E. (2009). Discrete choice methods with simulation. Cambridge university press.

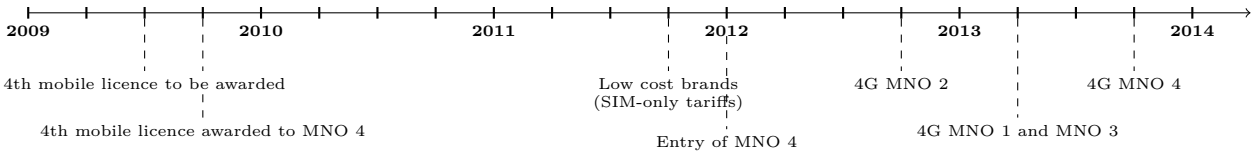
Zauberman, G. (2003). The intertemporal dynamics of consumer lock-in. *Journal of consumer research*, 30(3), 405-419.

Zauberman, G., and Lynch Jr, J. G. (2005). Resource slack and propensity to discount delayed investments of time versus money. *Journal of Experimental Psychology: General*, 134(1), 23.

Appendix A

Industry background

Figure A.1: Timeline of entry and launch of 4G services in the focal country



Note: *MNO* abbreviates Mobile Network Operator. *4G* corresponds to the introduction of LTE services by the mobile operators.

Estimation results

Table A.1: Results from the counterfactual analyses

	Individuals	Δ Consumer Surplus		Price of sim-only tariffs		Price of tariffs with handset	
		Mean	St. D.	Mean	St. D.	Mean	St. D.
Baseline	10,738	0	0	35.85	23.22	44.07	28.57
Scenario 1	10,738	-6.58	12.14	35.85	23.22	45.66	29.73
Scenario 2	10,738	-9.23	16.20	37.82	24.15	45.66	29.73
Scenario 3	10,738	-23.13	22.90	100,000	0.00	44.07	28.57
Scenario 4	10,738	-32.95	35.06	100,000	0.00	45.66	29.73

Note: Simulations with 10,738 consumers. Changes in consumer surplus are in comparison to the observed scenario, i.e. with observed (decreasing) prices and the introduction of sim-only tariffs. Scenario 1: SIM-only tariffs are introduced (observed prices) and co-exist with tariffs with handsets (prices April 2011). Scenario 2: SIM-only are introduced (prices April 2011) and co-exist with tariffs with handsets (prices April 2011). Scenario 3: SIM-only tariffs are not introduced. Only tariffs with handset (observed prices). Scenario 4: SIM-only tariffs are not introduced. Only tariffs with handset (prices April 2011).

Table A.2: Main estimation results on determinants of consumers' choices

Conditional Logit Dependent Variable : Alternative is chosen (0/1)	(1) Model I		(2) Model II		(3) Model III		(4) Model IV	
Prices								
Upfront cost of handset (α_1)	-0.008***	(0.00)	-0.009***	(0.00)	-0.009***	(0.00)	-0.009***	(0.00)
Present value of future costs (α_2)	-0.003***	(0.00)	-0.003***	(0.00)	-0.003***	(0.00)	-0.003***	(0.00)
Tariff characteristics								
Data allowance								
500 MB=1	1.152***	(0.03)	1.160***	(0.03)	1.116***	(0.03)	1.123***	(0.03)
1 GB=1	1.888***	(0.05)	1.883***	(0.05)	1.691***	(0.05)	1.704***	(0.05)
2 GB=1	1.947***	(0.05)	1.951***	(0.06)	1.948***	(0.06)	1.967***	(0.06)
4 - 6 GB=1	1.621***	(0.06)	1.637***	(0.07)	1.773***	(0.07)	1.793***	(0.07)
10 GB=1	2.502***	(0.10)	2.499***	(0.12)	2.853***	(0.13)	2.893***	(0.13)
Calls: Allowance	0.000	(.)	0.000	(.)	0.000	(.)	0.000	(.)
Unlimited	0.912***	(0.04)	0.928***	(0.05)	1.077***	(0.05)	1.093***	(0.05)
Calls: Allowance × Minutes	0.002***	(0.00)	0.002***	(0.00)	0.001***	(0.00)	0.001***	(0.00)
Fixed broadband=1	1.579***	(0.05)	1.630***	(0.05)	1.756***	(0.05)	1.769***	(0.05)
SIM-only no commitment	-0.650***	(0.04)	-0.524***	(0.04)	-0.675***	(0.04)	-0.680***	(0.04)
SIM-only 12 months contract	-2.646***	(0.05)	-2.548***	(0.06)	-2.815***	(0.06)	-2.827***	(0.06)
SIM-only, 24 months contracts	-1.787***	(0.07)	-1.632***	(0.07)	-1.716***	(0.07)	-1.718***	(0.07)
Handset sub, 12 months contract	-4.106***	(0.05)	-4.194***	(0.06)	-4.293***	(0.06)	-4.291***	(0.06)
Handset sub, 24 months contract	0.000	(.)	0.000	(.)	0.000	(.)	0.000	(.)
Handset characteristics								
Dummy Apple	6.494***	(0.07)	6.876***	(0.07)	6.918***	(0.07)	6.875***	(0.08)
Dummy Blackberry	2.509***	(0.06)	2.861***	(0.06)	2.891***	(0.06)	2.900***	(0.06)
Dummy HTC	-0.154	(0.09)	0.016	(0.09)	0.027	(0.09)	0.040	(0.09)
Dummy LG	-0.167*	(0.07)	-0.124	(0.07)	-0.112	(0.07)	-0.110	(0.07)
Dummy Motorola	-0.099	(0.12)	-0.086	(0.13)	-0.065	(0.13)	-0.051	(0.13)
Dummy Nokia	1.006***	(0.05)	1.011***	(0.05)	1.008***	(0.05)	1.014***	(0.05)
Dummy Samsung	1.539***	(0.05)	1.612***	(0.05)	1.635***	(0.05)	1.644***	(0.05)
Dummy smartphone=1	1.208***	(0.04)	1.242***	(0.04)	1.214***	(0.04)	1.244***	(0.04)
Months since handset release	0.011***	(0.00)	-0.007***	(0.00)	-0.007***	(0.00)	-0.007***	(0.00)
Height	0.018***	(0.00)	0.018***	(0.00)	0.019***	(0.00)	0.019***	(0.00)
Width	0.008*	(0.00)	-0.006	(0.00)	-0.008*	(0.00)	-0.006*	(0.00)
Thickness	0.045***	(0.01)	0.056***	(0.01)	0.058***	(0.01)	0.059***	(0.01)
Camera quality	0.081***	(0.01)	0.098***	(0.01)	0.102***	(0.01)	0.102***	(0.01)
Standby autonomy in hour	0.002***	(0.00)	0.002***	(0.00)	0.002***	(0.00)	0.002***	(0.00)
LTE=1 × 4G Tariff=1	1.316***	(0.07)	1.162***	(0.07)	1.315***	(0.07)	1.299***	(0.07)
Control functions								
Residuals from handset price regression			0.005***	(0.00)	0.006***	(0.00)	0.006***	(0.00)
Residuals from tariff price regression			0.001	(0.00)	0.002	(0.00)	0.002	(0.00)
Interactions with time					Yes		Yes	
Interactions with consumer characteristics							Yes	
Observations	3,851,776		3,851,776		3,851,776		3,851,776	
Number of consumers	10,738		10,738		10,738		10,738	
Log likelihood	-4.55e+04		-4.51e+04		-4.46e+04		-4.42e+04	

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The base outcome is Q2 2011 for quarters, 45-54 years old for age groups, and male for gender. Prices are interacted with quarters, age groups, and gender in Model IV.