Information Economics and Policy 000 (2018) 1–12

Contents lists available at ScienceDirect

Information Economics and Policy

journal homepage: www.elsevier.com/locate/iep

Receiver benefits and strategic use of call externalities in mobile telephony markets

Maciej Sobolewski[1],*, Mikołaj Czajkowski

Department of Economics, University of Warsaw, Dluga 44/50, 00-241 Warsaw, Poland

A R T I C L E I N F O

Article history:
Received 22 November 2017
Revised 16 February 2018
Accepted 15 March 2018
Available online xxx

JEL classification:
L1
L86
D62

Keywords:
Call externalities
Receiver benefits
Network effects
Mobile telephony
Stated preferences
Discrete choice experiment

A B S T R A C T

Recent models of network competition demonstrate the incentives for incumbent firms to reduce receiver benefits in an entrant's network through excessive off-net pricing. Theoretical reasoning behind the role of call externalities in limiting the market share of smaller networks assumes that receiving a call contributes to consumer utility. This paper tests this critical assumption with stated-preference data elicited from subscribers of mobile telephony in Poland. Our findings show that receiver benefits are a significant driver of mobile operator choice. Thus by reducing the volume of outgoing calls, larger networks can limit customer base growth of smaller rivals. Regulatory options for mitigating this effect are discussed. The size of market share gained by introducing a common off-net markup is low: 1.7–2.8% depending on the market segment. However under symmetric termination rates, an entrant would increase its market share by 6.1–8.5% at the expense of incumbents. In case of Poland, this would shorten the catch-up period from eight to five years.

1. Introduction

Economic externalities play a significant role in network industries. Telecommunication services, for example, generate various types of external benefits for their users. By controlling the extent to which those benefits are internalized, network operators can increase profits and improve their own competitive position in the market. In this paper, we show this empirically, using data from mobile telephony market in Poland. More specifically, we investigate how incumbent operators can realistically use call externalities to slow down the market share growth of late entrants (primarily in user or SIM card metrics). We also contribute to the discussion on the effects of making mobile termination rates (MTRs) asymmetric. Such regulation has been widely applied in Europe with the aim being to provide support by improving late entrants' revenues from interconnection. We show that in the presence of call externalities, asymmetric MTR could also have a negative effect on a small network, slowing down its market share growth.

The two primary sources of economic externalities in mobile telephony, are call and network benefits. Network externality is a well-known phenomenon which arises among subscribers of the same network. In this case the external benefit takes the form of savings from cheaper on-net calls.[2] On the other hand call externalities are an example of benefits generated in one network for subscribers of rival providers. They arise because telecommunication services generate two-sided benefits. For example, when a voice connection is established, not only the calling party but also the receiving party derives some positive utility. Under the *calling-party-pays* (CCP) regime, receiver benefits turn into a positive economic externality, which remains under the control of the call originating operator. In the presence of both types of externalities networks will typically implement the combination of a low on-net rate and an (excessively) high off-net rate to maximize the amount of network benefits available to a firm's own consumers while minimizing receiver benefits available to current or potential

* Corresponding author.
E-mail addresses: maciej.sobolewski@uw.edu.pl (M. Sobolewski), mc@uw.edu.pl (M. Czajkowski).

[1] Since July 2017 he is a research fellow at the Joint Research Centre of the European Commission. The scientific output expressed in this is study does not represent the position of the European Commission. The opinions and conclusions contained in this study are solely those of the authors.

[2] Several papers showed that in addition to their pecuniary nature, network effects in mobile telecommunications are localized, in the sense that the positive contribution to the subscriber utility function comes mainly from frequently called parties, such as family and friends (Corrocher and Zirulia, 2009; Maicas *et al.*, 2009b; Czajkowski and Sobolewski, 2011).

https://doi.org/10.1016/j.infoecopol.2018.03.003
0167-6245/

clients of rival firms. Such discriminatory pricing strategies are a good example of how operators maintain control over both types of external benefits, to improve profitability and defend market share.

Network effects have attracted the attention of researchers for almost three decades. There is a large body of theoretical literature and empirical evidence documenting their impact on consumer behavior and competition between providers in various network industries. Notably, in mobile telephony networks, externalities have incentivized incumbent operators to exercise termination-based price differentiation, which has raised some antitrust concerns.[3] In contrast, call externalities entered the economic research agenda later, after the wave of late entry that took place in several European countries as a result of 3 G licensing in 2001–2002. The interest in call externalities arose because of similar antitrust concerns related to the effects of price discrimination on the competitive position of late entrants. In a nutshell the reasoning points to a motivation to increase off-net prices in order to reduce receiver benefits for subscribers of rival operators. The incentives to use call externalities grow with the size of the network. Hence, incumbent operators will unilaterally set higher off-net prices for calls to a new entrant, depressing its volume of incoming calls and putting it into financial deficit in the access market. Antitrust literature has used the above mechanism to argue that call externalities may facilitate incumbent predatory pricing (Hoernig, 2007) or even a complete market foreclosure (López and Rey, 2016). Call externalities also have welfare impacts. For example, in the case of the T-Mobile/Orange merger case in the UK, Harbord and Hoernig (2015) show that post-merger welfare and consumer surplus are both decreasing functions of the strength of receiver benefits.

Theoretical studies suggested that call externalities are the source of competitive advantage over late entrants. By setting high off-net prices incumbents reduce the number of incoming calls and lower the attractiveness of the smaller network in the eyes of current and future subscribers (Jeon et al., 2004; Armstrong and Wright, 2009). However, this mechanism can be effective if and only if receiver benefits significantly contribute to consumer utility and thus can drive subscription choices. So far this critical assumption has not been tested empirically and various authors have either calibrated or used a generic value for the call externality parameter (Hurkens and López, 2012; Harbord and Hoernig, 2015). Given that call externalities fundamentally affect theoretical predictions and have implications for antitrust policy, access regulation and merger assessment, there is a need for more rigorous empirical evidence documenting their practical relevance on various mobile markets.

Our paper fills this gap by estimating the effect of call externalities on utility from mobile subscription. To do this, we used a dataset collected from a large-scale stated preference survey on prepaid and postpaid mobile phone users in Poland. The survey was administered to two samples of individual consumers representative of private users of prepaid and postpaid mobile services.[4] We controlled for call externalities with a price for incoming off-net calls which directly impacts call volumes received by respondents. A discrete choice experiment approach (Carson and Czajkowski, 2014) conveniently allowed for the inclusion and variance[5] of several elements, which determine individual utility from mobile subscription, such as termination-based discriminatory prices, personal network effects, switching costs and brand loyalty. We examine these factors and receiver benefits jointly in one model and identify their influence on the choice probabilities of particular operators. This analysis is followed by a policy exercise in which we simulate how market shares in Poland would react to the hypothetical reduction in off-net prices set by incumbent operators for calls terminating in a late entrant's network. Our results can be of practical relevance to operators and regulatory authorities in Poland and other countries where the discussion about the anti-competitive impact of call externalities has been lively. In particular, we illustrate how market shares would react to fully symmetric access charges. Our results suggest that higher termination rates may become an impediment for a late entrant in its market share expansion. Therefore as an entry assistance policy it should be applied for a limited period of time, as suggested by European Commission (2009).

Recently Rojas (2017) estimated receiver benefits on the Ecuadorian market. Overall receiver benefits from a unit of call are significant in magnitude, corresponding to 30–70% of sender benefits depending on the type of the contract and the type of the call. His study adopts a similar methodological approach to ours, but differs much with respect to experimental design. Rojas uses generic alternatives with only price-related attributes while skipping other determinants of choice. With respect to the strength of receiver benefit our results are of the same order of magnitude, although some differences occur. However, our framework allows us to go a step further and show the impact of call externalities on the choice of mobile subscriptions. We show how operators might realistically influence subscribers' behavior in the Polish market by affecting the size of receiver benefits with off-net pricing.

The remainder of the paper is organized as follows. In the next section, we review relevant literature devoted to call externalities. Section 3 presents the design of our study, characterizes the data and provides a description of the econometric framework. This is followed by the empirical results and the simulation of the counterfactual scenarios and policy implications related to the impact of alternative levels of off-net price asymmetry for market share changes. The last section summarizes the main results and draws conclusions.

2. Literature review

Call externalities have been studied in economics for over a decade as a component of two important theoretical problems: network competition under discriminatory tariffs and an optimal interconnection regime. With regards to the second issue, the main conclusion from the literature is that if both the sender and the receiver derive utility from a call, the optimal network utilization requires that both parties share the cost of a call (DeGraba, 2003; Hermalin and Katz, 2006). Given the large heterogeneity of two-sided benefits for individuals, such a shared optimal pricing scheme is not implementable. In practical terms this leaves the floor to one of the two extreme regimes where either the calling

[3] There were several competition cases in Europe concerning the abusive rate differentiation between 'on net' and 'off net' calls. For example, dominant operators Orange and SFR were fined in 2012 in France for introducing plans with unlimited on-net calls. The French Competition Authority argued that zero on-net rates resulted in excessive on-net/off-net differentiation leading to lock-in of subscribers and putting the late entrant into competitive and financial disadvantage. The latest entrant (Bouygues Télécom) could not effectively strike back as it encountered higher termination costs. The FCA considered the on-net/off-net price differential set by incumbents to not be justified by the difference in costs. Similar arguments have been raised by small operators in other countries as well as by the European Regulatory Group (ERG, 2008): "an on-net/off-net retail price differential, combined with significantly above-cost MTRs, can, in certain circumstances, tone down competition to the benefit of larger networks" (p. 97).

[4] Because subscribers whose mobile phones are exclusively or predominantly paid by their employer were excluded from the analysis, our samples are not representative of the entire prepaid and postpaid segments.

[5] Revealed behavioral data (assuming we had access to it) exhibits lower variability in explanatory variables and suffers from co-linearity, resulting in larger standard errors of the estimates and a risk of biased results (Louviere *et al.*, 2006).

or receiving party solely pays for the call. In what follows, we refer to the first stream of literature, to provide the basis for our study.[6]

As already noted, network competition models with call externalities bring radically new insights into the pricing incentives of large market players, equilibrium formation process and welfare considerations. Hermalin and Katz (2004) were the first to argue that omitting receiver benefits is unrealistic and would imply that the receiving party is generally reluctant to answer (and pay for) incoming calls.[7] Receiver benefits were introduced to the analysis of competition between interconnected networks by Jeon et al. (2004). They showed that in a duopoly setting, the equilibrium on-net prices decrease and off-net prices increase with the magnitude of call externalities. Hence, receiver benefits result in larger on-net/off-net price differential in equilibrium, compared to an otherwise identical market without them. The pricing structure set by each firm limits the level of off-net traffic and reduces the receiver benefits of rival networks' users while increasing network benefits available to their own subscribers. Importantly, off-net/on-net price differential grows with market share, indicating that the motives to overprice off-net calls against rivals increase with network size.

Armstrong and Wright (2009) extended the model of Jeon et al. (2004) to represent a symmetric oligopolistic mobile market interconnected with a single fixed network. They showed that the equilibrium mobile off-net price increases in line with the strength of receiver benefits and level of access charge, while it decreases in line with the number of mobile competitors. Call externalities in their model also have an impact on the socially optimal levels of fixed-to-mobile and mobile-to-mobile termination fees, pushing them below marginal termination costs. In their model large incumbent firms prefer higher access charges, if threatened by an entry, to induce call externalities in order to deter or limit that entry.

Hoernig (2007) analyzed the impact of call externalities on duopoly competition between asymmetrically sized networks with a regulated access charge. In equilibrium both networks fully internalize receiver utility of their own subscribers and set equal below-cost on-net prices. On the contrary, firms earn a positive markup on off-net prices, which increases with their own market share, the level of access charge and the size of receiver benefits. Hoernig also considers predatory behavior by the incumbent, which is distinct from Nash (strategic) pricing. With predation an incumbent further increases his off-net price and decreases fixed fees in order to drive an entrant out of the market or limit its profits. Such behavior is costly to the incumbent, but forces the entrant to reduce its off-net price and fixed-fee to fight for market share.[8]

In summary, the theoretical literature offers two main conclusions regarding call externalities. Firstly, in an equilibrium, the on-net/off-net price difference is higher in markets with call externalities than in markets without receiver benefits but which are otherwise identical. Secondly, a larger network will set a higher off-net price than a smaller network, reducing receiver benefits and lowering the attractiveness of the smaller rival. The latter conclusion has been demonstrated under reciprocal access charges. Asymmetric access charges generate an additional effect. Incumbents will price discriminate off-net calls with higher prices for connections terminated by the entrant. Exact conditions for market equilibrium in this case are complex and can be solved only numerically, see for example Hoernig (2014).

Receiver benefits are usually defined in theoretical models, as a fixed proportion parameter $\gamma \in [0, 1]$ which links the utility of the incoming call of length q with the utility of the outgoing call: $\gamma = u(q_{inc}) / u(q_{out})$ as in Jeon et al. (2004) or as a fixed monetary benefit $b > 0$ from a unit of incoming call, as in Armstrong and Wright (2009). As already noted, empirical evidence related to the estimation of this parameter is very scarce. Rojas (2017) estimates γ as the ratio of marginal utilities based on data from the stated-preference discrete choice experiment on Ecuadorian subscribers. He obtains $\gamma = 0.68$ for the on-net pair of incoming and outgoing calls (made and received within the same network) and $\gamma = 0.41$ for a pair of off-net calls. The size of receiver benefits is significantly greater for pre-paid users than post-paid subscribers (0.79 vs 0.27 for incoming calls). Hurkens and López (2012) calibrate the same parameter for Spain, based on observed difference between average off-net and on-net prices. They obtain a very small value of $\gamma = 0.07$ and eventually use larger levels in simulations. Sandbach and van Hooft (2010) report negligible values of 'residual' call externality: $b = 0.014$ and $b = 0.004$, based on multi-country data on price differentials. Their estimates are so small as they reflect only the un-internalized part of receiver benefits generated by more infrequent and perhaps less valuable calls received from outside the family and friends group.

3. Empirical evidence from the Polish mobile telephony market

3.1. Overview of the market

In a nutshell, the Polish mobile telephony market consists of three incumbent infrastructural operators[9] operating since 1996 and a fourth operator[10] who entered the market in 2007. In 2014 the four operators jointly had 98% of the market, pointing to a negligible role for virtual operators. Fig. 1 illustrates the evolution of market shares in the Polish mobile market. The late entrant had a significantly lower market share than the incumbent operators throughout the eight years of post-entry competition.[11] The fact that incumbents maintained a pervasive advantage for such a long period, despite the establishment of a national roaming agreement, points to the prominent role of consumer lock-in factors.[12] Fig. 2 shows retail and wholesale (access) pricing developments. In 2007 UKE (Office of Electronic Communications), the national regulatory authority, introduced asymmetric termination rates to support the late entrant and announced a scheme for gradual reduction of asymmetry (see *MTRs to incumbents* and *MTRs to entrant* in Fig. 2). Two years later, the incumbents started to set higher off-net prices to the late entrant than to the remaining larger networks (see the *off-net price to entrant* and *off-net price to incumbents* in Fig. 2). Initially, the level of asymmetry of the off-net calls prices was consistent with the asymmetry of MTRs. Later on however, incumbents kept their prices unchanged despite gradual reductions in MTRs. Importantly this led to larger markup being earned by incumbents on off-net calls to the entrant than on off-net calls to

[6] Harbord and Pagnozzi (2010) provide a comprehensive overview of this literature.

[7] The non-existence of receiver benefits is also clearly contradicted by the operation of the receiving-party-pays regime in a number of countries, including the US and Canada. Receiver benefits are not uniform and in exceptional cases (e.g., calls from telemarketing companies) could even be negative (Littlechild, 2006).

[8] Calzada and Valletti (2008) show a similar predation mechanism under negotiated access charges. Incumbents will choose to raise access charges to increase off-net price and lower the ex-post profitability of new entrants. López and Rey (2016) show that foreclosure does not have to be costly for the incumbent. Under sufficiently large network externalities and switching costs, incumbents can reach corner equilibrium and gain extra profits by raising access charges.

[9] PTK Centertel (Orange), PTC (T-Mobile) and Polkomtel (Plus).

[10] P4 (Play).

[11] In the explanatory note to its regulatory recommendation, EC expected the catch-up period to last for approximately four years (European Commission, 2009). This assessment seems to largely underestimate the role of externalities.

[12] Other factors, besides call externalities, that induce consumer lock-in are switching costs and personal network effects, see for example Czajkowski and Sobolewski (2016).

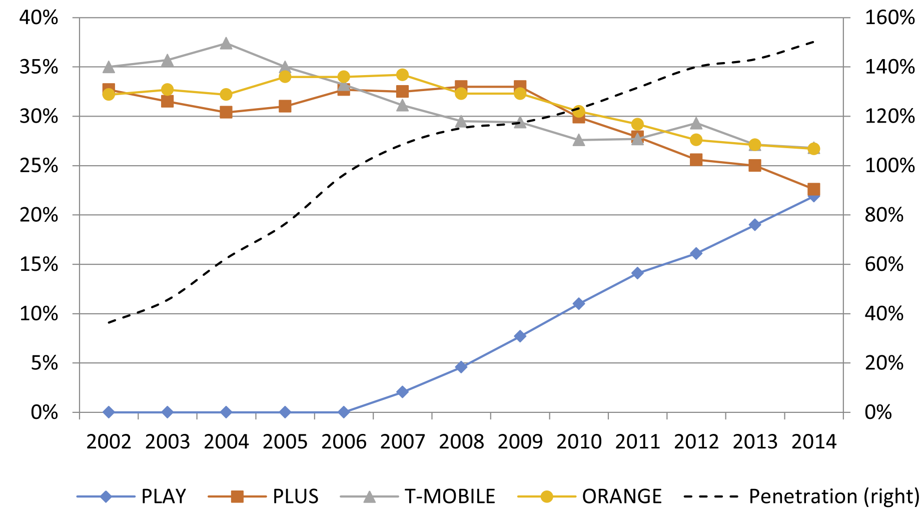

Fig. 1. Penetration in mobile telephony market in Poland and market shares (sim cards).
Source: annual reviews of the telecommunications market in Poland provided by the Office of Electronic Communications.

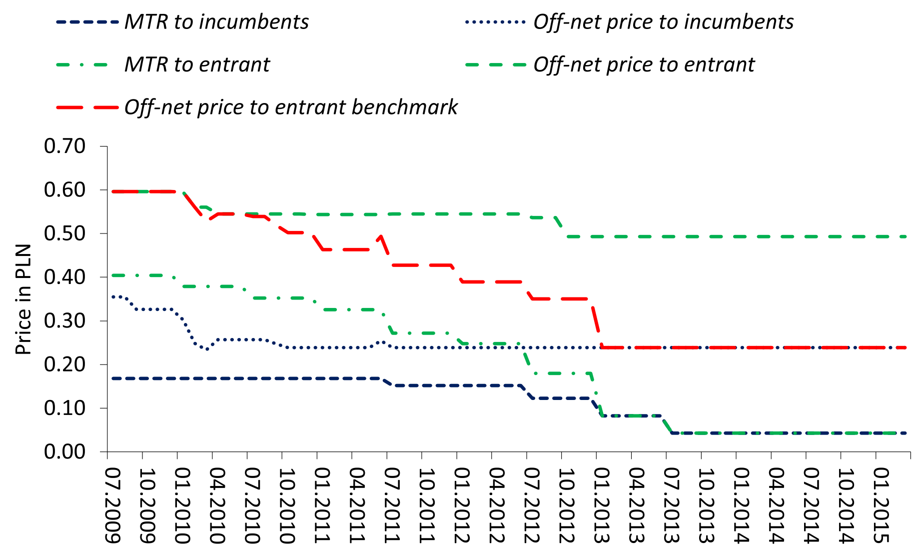

Fig. 2. Actual MTRs and marginal prices of off-net calls to entrant and incumbents. Data for postpaid subscribers between July 2009 and January 2015. The benchmark price of off-net calls to entrant network reflects the common markup rule.
Source: Market monitoring provided by Audytel S.A.

other large networks. Interestingly, the asymmetry of off-net call prices between incumbent networks and P4 (Play) started in April 2010 and continued even beyond the period of asymmetric regulation of termination rates.

This large discrimination in off-net pricing by incumbent operators could point to a collective predatory attempt against new the entrant in line with Hoernig (2007), providing an explicit rationale for regulatory intervention. Unfortunately disentangling predation from strategic (Nash) overpricing is not that easy. In Nash equilibrium with call externalities incumbents will also set higher off-net markup on calls terminated by smaller networks, because it depends on the ratio of market shares.[13] Hence more detailed examination of markup levels based on a formal model would be required.[14] Nevertheless, even in the case of pure Nash behavior, call externalities still incentivize incumbents to overprice off-net calls. Large price differentials might give cause for regulatory intervention on account of the abuse of the collective dominant position with the effect of harming the entrant and locking-in consumers.

In the policy exercise, we assume that any intervention would reduce the on-net/off-net price differential to a level which yields equal off-net markup in the market. With this yardstick a regulator could ensure that all prices consistently reflect (unequal) marginal costs. In Fig. 2 we illustrate the benchmark off-net prices for calls terminated by an entrant under a common markup rule (see *the off-net price to entrant benchmark*).[15] In what follows, we check how such potential regulation, which effectively drives down the off-net price to the entrant, would influence market shares in the market.

[13] More specifically the Lerner index for off-net calls has the following form: $L_{ij} = (\alpha_i/\alpha_j)\gamma$ where α_i, α_j are the market shares of respectively the originating and the terminating network and γ is the receiver benefit parameter. Note that the size of markup does not depend on the access charge (contrary to the level of off-net price).

[14] We have made such an exercise based on Hoernig (2007)'s model and the results point to the lack of predatory behavior against the late entrant. This conclusion should be however treated with great caution as we had to adopt simplifying assumptions that allowed us to reduce the actual oligopoly setting to a duopoly game.

[15] The benchmark off-net prices of incumbents for calls terminated in an entrant's network are set according to the same percentage markup as off-net prices for calls terminated in incumbent networks, but applied to a higher termination rate.

3.2. Development of the empirical study

A stated preference questionnaire that encompasses hypothetical choices revealing respondents' true preferences typically starts with general introductory questions and collects information about the status-quo–in our case, questions referring to respondents' current use of a mobile phone. Next, it introduces a contingent scenario and the choices that are about to follow; at this point, the choice alternatives, attributes, and their levels are described. The respondent is then asked to review the choice situations and select the alternative that he or she prefers from among those presented.[16] In the last part of the questionnaire, the respondent's socio-demographic characteristics are collected.

In our case, respondents were asked to choose a new mobile phone plan that they thought was the best for them out of the four hypothetical alternatives.[17] The hypothetical new plans could be provided by one of the four major providers operating in Poland. Each of the alternatives was described with the following 6 attributes:

(1) The brand name of the mobile operator's network.[18]
(2 & 3) The average on-net and off-net price of a call.
(4) The average price of incoming calls from other networks.
(5 & 6) The size of the 'family and friends' and 'other people' in the same network.

The first attribute is almost always included in preference studies regarding mobile services, for example Maicas et al. (2009a), Grzybowski and Pereira (2011) and Sobolewski and Czajkowski (2012). We introduce brand effects as alternative-specific constants; hence, we can jointly control for all systematic differences in the perception of qualitative factors such as call quality, network coverage or customer service. The next two attributes (on-net and off-net prices) reflected the basic structure of termination-based tariffs, which allowed us to incorporate call and network externalities as the drivers of customer behavior. The fourth attribute, i.e., the price of incoming calls from other networks, was included to indirectly indicate the magnitude of receiver benefits. Because other subscribers can be expected to adjust their call volumes due to price changes, this attribute can be used to control for call externalities.[19] The last two attributes reflect personal and absolute network effects associated with each of the alternatives. The category 'family and friends' was defined as all persons with whom the respondent maintains regular contact on private grounds. 'Others' consisted of all other people whom the respondent contacts irregularly, such as shops, offices, and distant friends, or people whom he or she does not contact at all but are still connected to the same network. This attribute was therefore equivalent to each operator's hypothetical customer base. We have differentiated between those two sources of network benefits because, according to the growing body of empirical evidence, network effects are not homogeneous across all individuals in the same network but are localized within a small subset constituting the social network of a particular subscriber (Corrocher and Zirulia, 2009; Maicas et al., 2009b; Czajkowski and Sobolewski, 2011)

Table 1
List of attributes and attribute levels used to describe choice alternatives.

Choice attributes	Levels
Brand of the operator	• Orange • T-Mobile • Plus • Play
On-net price (PLN per minute)	• 0.10 • 0.20 • 0.30
Off-net price (PLN per minute)	• 0.20 • 0.30 • 0.50
Price of call incoming calls from other networks, paid by the person originating connection (PLN per minute)	• 0.20 • 0.30 • 0.50
share of 'family and friends' group in the same network	• 25% • 50% • 75%
Share of 'others' in the same network	• 25% • 50% • 75%

The levels of the attributes, particularly on-net, off-net and incoming call prices, and the share of 'family and friends' in the same network reflect actual market conditions and the average levels actually experienced by respondents. These levels are summarized in Table 1. Variation in attribute levels was tested in the qualitative analysis to ensure sufficient responsiveness of respondents.

The attributes and their levels were carefully explained to respondents in the survey. They were asked to assume that the alternatives were exactly the same with respect to any characteristics that were not explicitly listed in the choice situations (e.g., the price of a text message).[20]

Each respondent was presented with 12 randomized choice tasks, each consisting of four alternative 'new plans'. The combinations of the attribute levels presented in each of the choice tasks (i.e., the experimental design) were selected in a Bayesian efficient way (Ferrini and Scarpa, 2007; Scarpa and Rose, 2008), i.e., to minimize the determinant of the expected AVC matrix of the estimates (*D-error*) given the priors of the parameters of a representative respondent's utility function derived from a pilot survey.[21] An example of a choice card is given in Table 2.

The main survey was administered to a quota-controlled sample of 1,001 prepaid and 1,029 postpaid mobile phone users in Poland

[16] This represented the situation each subscriber faces when his contract finishes or when the conditions of prepaid offers change. Although we did not offer the respondents the possibility of sticking to their status quo plan, this is also usually not the case when the contract expires / prepaid conditions change. We acknowledge, however, that there could be considerable inertia effect that we controlled for in the econometric modelling by making preferences for the operators heterogeneous with respect to respondents' current operator.

[17] As noted by one of the reviewers, it is not unusual for consumers to subscribe to two or more mobile services. This option was not made possible in our study. Where respondents declared they had more than one mobile service, we asked them to consider only one of them, the one that could be considered to be their 'main' number. This is because the aim of our study was to investigate consumers' preferences for the attributes of mobile services. We decided that making choices with respect to one's main mobile service was enough to reveal them.

[18] In our preliminary qualitative in-depth interviews, respondents associated various qualities with different operators (brands). For this reason, we have included the four brands of infrastructural operators on the Polish market: Orange, T-Mobile, Plus and Play.

[19] Alternatively, one could use a traffic-based approach, which directly focuses on the actual source of receiver benefits. We decided not to use this approach, however, because it seems more suitable for conducting assessment exercises related to various access charge policies.

[20] The development of the questionnaire was conducted according to state-of-the-art recommendations for stated preference studies, including thorough qualitative pre-testing, to make sure the discrete choice experiment was understandable and credible to respondents.

[21] Each design used three blocks, i.e. it had 36 rows in total. We did not use fixed blocks but instead for the first respondent we drew 12 random choice tasks out of the total 36, for the next respondent we drew 12 out of the remaining 24, and next respondent saw the remaining 12 (in a random order). This procedure assures that each choice task was used an almost equal number of times, which would not be the case if 12 rows were drawn from the 36 rows for each respondent each time. Using a fixed blocks design optimized for the MNL model is an artefact of an old method of paper (not computerized) surveys and there is some evidence that it is less efficient than randomizing choice tasks for respondents Czajkowski and Budziński (2016). There was a separate design for prepaid and postpaid users. The order of choice tasks and alternatives as presented to respondent was randomized.

Please cite this article as: M. Sobolewski, M. Czajkowski, Receiver benefits and strategic use of call externalities in mobile telephony markets, Information Economics and Policy (2018), https://doi.org/10.1016/j.infoecopol.2018.03.003

Table 2
Example of a choice card used in the survey (translation).

Which of the following mobile phone operators' offers would you consider the best for yourself?				
Operator	Orange	T-Mobile	Plus	Play
On-net price per minute (PLN)	0.2	0.1	0.3	0.2
Off-net price per minute (PLN)	0.2	0.5	0.5	0.2
Price of incoming off-net call, per minute (PLN)	0.3	0.3	0.3	0.3
'Family and Friends' in the same network	25%	25%	75%	75%
'Others' in the same network	50%	50%	25%	75%
Your choice	☐	☐	☐	☐

Table 3
Descriptive statistics of the prepaid and postpaid samples.

A. Demographics					
Age [years]	*18–22*	*23–35*	*36–55*	*56–65*	*mean*
Postpaid ($N = 1029$)	5%	36%	47%	12%	39.3
Prepaid ($N = 1001$)	13%	32%	41%	14%	38.2
Gender	*women*	*men*			
Postpaid	49%	51%			
Prepaid	53%	47%			
Education	*primary*	*vocational*	*secondary*	*higher*	
Postpaid	1%	7%	43%	49%	
Prepaid	2%	9.5%	47.5%	41%	
Income distribution [PLN]	*0–2000*	*2001–3000*	*3001–4000*	*above 4000*	*no answer*
Postpaid	32%	29%	15%	12%	12%
Prepaid	50%	21%	8%	7%	14%
B. User profile					
Operators' shares	*Orange*	*Play*	*Plus*	*T-Mobile*	*others*
Postpaid	30%	28%	21%	20%	1%
Prepaid	35%	26%	19%	16%	4%
Total sample [(a)]	31.8%	27.3%	20.3%	18.3%	2.2%
Official statistics [(b)]	27.7%	25.8%	22.6%	20.8%	3.2%
Duration of outgoing calls per day [min]	*0–20*	*21–40*	*41–60*	*above 60*	*mean*
Postpaid	45%	22%	18%	15%	43.4
Prepaid	65%	16%	10%	9%	27.3
Average monthly expenditure [PLN]	*0–20*	*21–40*	*41–60*	*above 60*	*mean*
Postpaid	7%	26%	33%	34%	63.5
Prepaid	40%	45%	11%	4%	29.1
Number of previous operator changes	*0*	*1*	*2*	*more than 2*	*do not know*
Postpaid	38%	38%	15%	8%	1%
Prepaid	45.5%	30%	14.5%	8%	2%
Size of 'family and friends' group [persons]	*1–3*	*4–5*	*6–10*	*11–15*	*above 15*
Postpaid	12%	24%	38%	10%	16%
Prepaid	19.5%	28.5%	34%	8%	10%
Share of calls to 'family and friends' in total outgoing traffic [%]	*0–20*	*21–40*	*41–60*	*61–80*	*above 80*
Postpaid	4%	12%	21%	41%	22%
Prepaid	8%	13%	18%	34%	27%

Notes: a) Applied weights reflect sizes of both segments in the pool of active users based on UKE (2016a). Due to lack of more precise data, the weights are assumed to be uniform across operators. b) Source UKE (2016b)

in June 2015.[22] The survey had a computer-assisted-web-interview format, and lasted approximately 20 minutes. Sampling and data collection was conducted by a professional public opinion polling agency.[23] The response rate was 29%. Because each respondent was faced with 12 choices, our data set consists of 12,012 and 12,348 choice observations, respectively.

3.3. Characteristics of the samples

The demographic and usage profiles clearly differ between the samples of prepaid and postpaid subscribers (see Table 3, panel A). Prepaid users are less educated and have lower earnings than postpaid users. Although the average age is similar, the postpaid sample is characterized by a larger share of middle-aged users, while the prepaid sample has larger shares of individuals from the youngest (below 22) and the oldest (above 55) age groups. This pattern corresponds well to observed differences in income distributions and usage profiles. Prepaid users generate much less traffic than postpaid customers and hence pay lower bills per month. The prepaid sample contains twice as many people who mainly receive connections, as suggested by a lower share of calls to family and friends in the total outgoing traffic, which might be an indication of their greater sensitivity to call externalities.

Both types have similar exposition to network effects. The median share of connections to family and friends in the total duration of outgoing calls is above 70% in both groups, whereas the average size of the social network is only slightly smaller in the prepaid sample (7.8 vs. 9.2 persons).

In summary, the prepaid service attracts the youngest and the oldest respondents. Both groups originate fewer connections but receive more calls. In contrast, postpaid subscribers are more intensive users of mobile voice services. They maintain regular contact with a larger group of family and friends and originate more calls to people outside their social network. With respect

[22] Both samples were representative with respect to the age structure (18-65 years) and region.

[23] IPSOS Poland.

to demographics, postpaid users are on average better educated and have higher incomes. Lacking census data we can only assess the reliability of the joint sample based on market share distribution.[24] Our sample shows the same order of market players as official data published by national regulatory authorities (see Table 3). We observe slight under-representation of T-Mobile and Plus subscribers, but this can be attributed to the filtering out of more users with business phones or employee-employer cost sharing schemes. For many years both operators have focused respectively on small and medium size companies and state-owned enterprises and not on the mass market. We also note that official statistics include a huge number of inactive SIM cards, while our study captures only active users. Despite these factors the level of discrepancies in the market share data is quite small. In what follows, we model preferences of both groups separately and investigate how sensitive they are with respect to specific components of mobile services.

3.4. Econometric framework

The discrete choice experiment data can be used to formally model respondents' utility functions, i.e., to quantify the extent to which each attribute influences the choices of prepaid and postpaid subscribers. Given estimated choice models, it is possible to conduct a scenario analysis and evaluate how subscribers from prepaid and postpaid segments will change their choices in response to alternative levels of asymmetry in the prices of incoming calls. This makes it possible to assess the impact of call externalities on the market shares of mobile operators.

Formally, discrete choice modeling is based on the random utility model (McFadden, 1974). In this framework, the utility function of a consumer i from choosing an alternative$j$ in a choice situation t can be expressed as follows:

$$U_{ijt} = \mathbf{x}_{ijt}\boldsymbol{\beta} + \varepsilon_{ijt}, \tag{1}$$

where $\boldsymbol{\beta}$ is the vector of utility parameters, $\mathbf{x}$ is the vector of alternative-specific attributes, and ε is the random component, representing the joint influence of all unobserved factors that influence decision-making (Manski, 1977). By assuming that the random component is standard type-1 extreme value distributed, the multinomial logit (MNL) model is obtained with a convenient closed-form expression for the choice probability:

$$P(j|J) = \frac{\exp\left(\mathbf{x}_{ijt}\boldsymbol{\beta}\right)}{\sum_{k=1}^{J}\exp\left(\mathbf{x}_{ikt}\boldsymbol{\beta}\right)} \tag{2}$$

In what follows, we apply a mixed logit (MXL) extension of the model which allows us to take the respondents' preference heterogeneity into account, as it has been shown to substantially improve model performance in the case of preferences for mobile telecommunications (Czajkowski and Sobolewski, 2016). In the MXL model, the preference parameters are individual specific, following an a priori specified multivariate distribution $\boldsymbol{\beta}_i \sim f(\mathbf{b}, \boldsymbol{\Sigma})$, where $\mathbf{b}$ is a vector of population means and $\boldsymbol{\Sigma}$ represents a (possibly non-diagonal) variance-covariance matrix. By assuming a structured variation of individual tastes in the sample, in the form of individual-based parameters, the MXL model is more realistic and typically yields a much better fit to the data (Hensher et al., 2015). This comes at the cost of a more complicated estimation procedure; however, the unconditional probability of the individual i choosing an alternative j in situation t is an integral of standard logit probabilities over a density individual utility parameter (Train, 2009). Because mixed logit probabilities involve integrals that do not have closed forms, estimation requires the application of e.g., the maximum simulated likelihood method. As a result, the simulated log-likelihood function becomes the following:

$$\log L = \sum_{i=1}^{I}\log\frac{1}{D}\sum_{d=1}^{D}\prod_{t=1}^{T_i}\sum_{j=1}^{J} y_{ijt}\frac{\exp\left(\mathbf{x}_{ijt}\boldsymbol{\beta}_{id}\right)}{\sum_{k=1}^{J}\exp\left(\mathbf{x}_{ikt}\boldsymbol{\beta}_{id}\right)}, \tag{3}$$

where y_{ijt} is a dummy variable equal to 1 if a respondent i selected an alternative j in a choice situation t and 0 otherwise and D represents the number of simulated points. Maximizing the log-likelihood function in (3) gives estimates for the parameters.[25]

3.5. Results

Table 4 presents the results of the MXL model used to estimate the parameters of subscribers' utility functions.[26] The estimated coefficients reflect respondents' marginal utilities associated with changes in the levels of the attributes (e.g., price increase), and as a result, changes in the probability of selecting an alternative. Consumers' preference heterogeneity is incorporated into the model by making the utility function parameters random according to some a priori selected parametric distribution–for this reason, each attribute is associated with the estimate of the mean and standard deviation of its distribution in the population.[27] We note large and significant estimates of the standard deviations (relative to the means) which indicate the presence of substantial unobserved preference heterogeneity with respect to most choice characteristics. Although coefficients for mean do not have a direct interpretation,[28] their signs (in the case of normal distribution) reflect whether the attributes are perceived to be good or bad, whereas their relative values indicate their relative importance. In addition, by calculating the ratios of the parameters, it is possible to derive marginal rates of substitution; if the attribute in the denominator is monetary, the result can be interpreted as the marginal willingness to pay, i.e., the exchange rate at which a respondent is willing to trade the change in an attribute for money. In particular, marginal rates of substitution between price of incoming calls and price of outgoing calls can be interpreted as the magnitude of receiver benefits (see Table 5).

The first of the attributes (status quo inertia) is an alternative-specific constant associated with each respondent's current operator. Its significance shows that, on average, respondents prefer their current operator to the alternatives – a sign of consumers sorting themselves into the operators they prefer, growing accustomed to their current operator and not wanting to change, or any other inconveniences associated with switching (despite the availability of quick and costless portability procedures). Status quo inertia has been confirmed in previous studies (Czajkowski and Sobolewski, 2016) and might be interpreted as brand loyalty or transaction costs.

[24] Since no census data for prepaid and postpaid segments was available for comparison, we cannot make a statistical assessment of the representativeness of our sample. However, we could still expect some systematic differences, because our sample does not include business phones or private phones with employee-employer cost sharing schemes. This should not distort the expected magnitude of receiver benefits, because it is likely to be independent from any arrangements related to cost sharing scheme for mobile phones.

[25] The models were estimated in Matlab. The software used here (estimation package for DCE data) is available at github.com/czaj/DCE under CC BY 4.0 license.

[26] The dataset, additional results and estimation codes are available from the authors upon request.

[27] We selected the parametric distribution for each attribute based on the model fit criteria (lognormal distributions for inertia effects and the price coefficients substantially improved the model fit. For log-normally distributed parameters, the coefficients of the underlying normal distribution are reported.

[28] The utility function is ordinal; the coefficients are confounded with the scale coefficient, because the variance of the utility function error term is normalized.

Please cite this article as: M. Sobolewski, M. Czajkowski, Receiver benefits and strategic use of call externalities in mobile telephony markets, Information Economics and Policy (2018), https://doi.org/10.1016/j.infoecopol.2018.03.003

Table 4
Estimates of the utility function parameters for postpaid and prepaid subscribers.

Attributes of mobile subscription plans	*Distribution*	Postpaid		Prepaid	
		Mean (s.e.)	*Standard deviation (s.e.)*	*Mean (s.e.)*	*Standard deviation (s.e.)*
Status quo inertia	Lognormal	−0.2149*** (0.0838)	1.5661*** (0.1065)	0.3206*** (0.0835)	1.4688*** (0.1039)
Orange vs. Play (operator-specific constant)	Normal	−0.2746*** (0.1123)	1.5055*** (0.0891)	−0.3364*** (0.1174)	1.5929*** (0.1027)
T-Mobile vs. Play (operator-specific constant)	Normal	−0.4320*** (0.1107)	1.5203*** (0.0897)	−0.5623*** (0.1171)	1.7902*** (0.1009)
Plus vs. Play(operator-specific constant)	Normal	−0.2592*** (0.1085)	1.4262*** (0.0865)	−0.3111*** (0.1122)	1.5633*** (0.0990)
On-net calls price per minute (PLN)	- Lognormal	2.1814*** (0.0577)	1.1412*** (0.0540)	2.1776*** (0.0667)	1.3144*** (0.0637)
Off-net calls price per minute (PLN)	- Lognormal	1.5915*** (0.0832)	1.4283*** (0.0675)	1.4897*** (0.0913)	1.6918*** (0.0782)
Incoming off-net calls price per minute (PLN)	- Lognormal	0.5138*** (0.1691)	1.4786*** (0.1071)	0.3645*** (0.1375)	1.6471*** (0.0878)
Share of friends and family using the same operator (%)	Normal	0.9718*** (0.2023)	4.1352*** (0.1993)	0.5746*** (0.2030)	3.8925*** (0.1906)
Share of other people using the same operator (%)	Normal	−0.0091 (0.1476)	2.2718*** (0.1506)	−0.1722 (0.1485)	2.1344*** (0.1599)
Model diagnostics					
Log-likelihood (constants)		−17,011.16		−16,458.07	
Log-likelihood		−10,082.30		−9,014.88	
McFadden's Pseudo-R^2		0.4073		0.4523	
Ben-Akiva Lerman's Pseudo-R^2		0.4830		0.5171	
AIC/n		1.6418		1.5100	
n (no. of observations)		12,348		12,012	
k (no. of parameters)		54		54	

Notes: ***, ** and * indicate 1% and 5% significance levels, respectively. Parameter estimates represent moments (mean, standard deviation) of the distribution of individuals' preferences (utility function coefficients). Standard errors provided in parentheses. All parameters were assumed to be normally or log-normally distributed (whichever resulted in a better fit of the model) and correlated. For log-normal distributions the estimated coefficients of the underlying normal distribution are provided. The estimates of the correlation coefficients are available in the online supplement to this paper at http://czaj.org/research/supplementary-materials.

Table 5
Estimates of selected statistics for receiver benefit parameter distribution.

Sample statistic		Postpaid		Prepaid	
		$\breve{\gamma}_{off}^{off}$	$\breve{\gamma}_{on}^{off}$	$\breve{\gamma}_{off}^{off}$	$\breve{\gamma}_{on}^{off}$
Mean	est.	0.48***	0.35***	0.53***	0.31***
	s.e.	(0.07)	(0.03)	(0.06)	(0.03)
	95% c.i.	(0.37; 0.65)	(0.29; 0.44)	(0.42; 0.67)	(0.25; 0.37)
Median	est.	0.36***	0.20***	0.35***	0.17***
	s.e.	(0.04)	(0.02)	(0.04)	(0.01)
	95% c.i.	(0.28; 0.47)	(0.16; 0.26)	(0.28; 0.44)	(0.14; 0.21)
q 0.025	est.	0.08***	0.02***	0.06***	0.02***
	s.e.	(0.01)	(0.007)	(0.01)	(0.004)
	95% c.i.	(0.05; 0.12)	(0.01; 0.04)	(0.04; 0.08)	(0.01; 0.03)
q 0.975	est.	1.54***	1.60***	2.07***	1.41***
	s.e.	(0.34)	(0.23)	(0.32)	(0.17)
	95% c.i.	(1.05; 2.40)	(1.23; 2.16)	(1.54; 2.80)	(1.11; 1.80)

Notes: ***, ** and * indicate 1% and 5% significance levels, respectively. The coefficients represent simulated (parametrically bootstrapped) mean, median and two quantiles (0.025, 0.975) of the distribution of individuals marginal rates of substitution between incoming off-net calls and originating off-net calls ($\breve{\gamma}_{off}^{off}$) and marginal rate of substitution between incoming off-net calls and originating on-net calls ($\breve{\gamma}_{on}^{off}$).

The negative coefficients of the means of the normally distributed parameters for operator-specific constants show that Orange, T-Mobile and Plus are all (on average) less preferred than the reference (Play), although in each case there is substantial heterogeneity of brand preferences, as indicated by the relatively high estimates of the standard deviations.[29] All else being equal (and controlling for status quo inertia[30]), brand effects represent systematic differences in the perception of soft prerequisites such as call quality, customer service or brand image between the operators, that are not controlled by other attributes of the choice (e.g., prices,

[29] By 2015 it had reached similar market share to other operators. In addition, 2015 was also the year when Play launched a large-scale promotional campaign that likely influenced its perception in consumers' eyes. In the earlier years, Play was found to be considered inferior to other operators (Czajkowski and Sobolewski, 2011; Sobolewski and Czajkowski, 2012)

[30] For SQ Table 4 presents coefficients for mean and standard deviation of the underlying normal distribution $N(\mu, \sigma)$. Point estimates for the mean and variance of the log-normally distributed coefficient $LN(m,s)$ can be derived with textbook formulas: $m = e^{\mu+\sigma^2/2}$; $s = \sqrt{(e^{\sigma^2} - 1)e^{2\mu+\sigma^2}}$. We note that the status quo inertia has a considerably larger magnitude than brand effects (mean effect equals 2.73). This indicates that, other things being equal, switching costs discourage subscribers from changing current operator even if it is perceived as inferior to the competitors.

Please cite this article as: M. Sobolewski, M. Czajkowski, Receiver benefits and strategic use of call externalities in mobile telephony markets, Information Economics and Policy (2018), https://doi.org/10.1016/j.infoecopol.2018.03.003

shares of family and friends on net). We use them to control for respondents' overall preferences for the operators, while the main focus of our study is the influence of on-net, off-net and incoming off-net calls prices. In other words, even though one operator could be preferred to another, and these preferences can change over time, we are still able to observe the orthogonal effect of call prices and simulate what the choice probabilities would be if the prices were different (while keeping the preferences for operators constant across scenarios). Similarly to earlier studies (Maicas et al., 2009b; Sobolewski and Czajkowski, 2012; Czajkowski and Sobolewski, 2016), we find that network effects can be an important driver of consumers' choices but are largely limited to the 'friends and family' group.

As expected, all three (negatively log-normally distributed) price coefficients show that consumers' utility sharply decreases with price. The price of on-net calls is the most important, which is not surprising given that people tend to group in the same network and make the dominant share of calls to their friends and family. The price of incoming calls – paid by other subscribers to call a respondent in a different network – has the lowest, albeit significant impact on respondents' utility, and hence on the probability of choosing an operator with more expensive incoming calls. This result confirms the sensitivity of subscribers to receiver benefits and opens the floor for considerations about the impact of call externalities on the choice of operator and competition between operators.[31]

Finally, what is the strength of receiver benefits in proportion to the sender benefits? Given the vector estimated coefficients of utility function $\boldsymbol{\beta}$ we are able to provide implicit estimates of the receiver benefit parameter γ understood as the ratio of marginal utilities, according to the equations below:

$$\begin{cases} \breve{\gamma}_{off}^{off} = \dfrac{\partial U/\partial price_{incoming\_offnet}}{\partial U/\partial price_{outgoing\_offnet}} = \beta_{price\_incoming\_offnet}/\beta_{price\_outgoing\_offnet} \\ \breve{\gamma}_{on}^{off} = \dfrac{\partial U/\partial price_{incoming\_offnet}}{\partial U/\partial price_{outgoing\_onnet}} = \beta_{price\_incoming\_offnet}/\beta_{price\_outgoing\_onnet} \end{cases}$$

The first equation denotes the marginal rate of substitution between incoming off-net calls and originating off-net calls while the second equation denotes the marginal rate of substitution between incoming off-net calls and originating on-net calls. We simulate both measures of γ separately for prepaid and postpaid users (see Table 5).

Our estimates of mean receiver benefits are larger for prepaid users than for postpaid, as in Rojas (2017), but the difference is small.[32] We note that mean receiver benefits are larger in relation to outgoing off-net calls ($\breve{\gamma}_{off}^{off} > \breve{\gamma}_{on}^{off}$), which indicates that on-net calls are considered to be more valuable. As we control for price differences, this points to the role of on-net calling clubs. Interestingly, all estimates of the median value of receiver benefits are significantly smaller than average. These effects can be explained by respondents who do not make outgoing calls and hence have a utility parameter for price of outgoing calls close to zero. These respondents, located in the upper percentiles of the distribution, as shown in Table 5, inflate the mean. The proportion of users who are particularly reluctant to make outgoing off-net calls is likely to be greater in prepaid segment, hence the mean value of $\breve{\gamma}_{off}^{off}$ is affected more strongly. Median values indicate no difference between segments in the magnitude of receiver benefits, hiding the effect of a longer right tail in the distribution of γ in the prepaid segment.

3.6. Simulated policy scenarios

The results presented in the preceding section demonstrated that receiver benefits are indeed a significant determinant of consumers' operator choice. Hence, in line with theoretical insights, by engaging in strategic overpricing of off-net calls larger operators can discourage subscribers from joining smaller networks. The larger the receiver benefits are, the larger the loss of a market share on the part of an entrant would be. In this section, we investigate the outcomes of the two regulatory policies which could be put in place in order to mitigate these effects.

Our baseline scenario reproduces average market conditions in 2010–2012, when incumbent operators engaged in excessive (as defined in Section 3.1) discriminatory off-net pricing.[33] Scenario 1 assumes that incumbents earn the same markup on off-net calls in all directions. Under this policy off-net price for calls terminated by the entrant would have to be reduced to reflect MTR asymmetry. Scenario 2 assumes that MTRs to the entrant and incumbents are on the same level and a common markup rule mandates uniform off-net pricing on the market at the current level of off-net prices to incumbents. In the construction of both scenarios we ignore possible adjustments of mobile tariffs that could take place in equilibrium. In particular, we assume that on-net prices as well as off-net prices between incumbent networks are not affected. Table 6 summarizes the main characteristics of the baseline and two counterfactual scenarios.

Knowledge of the respondents' utility function parameters and their individual-specific characteristics (such as the share of friends and family using the same operator or their current subscription) allows us to calculate the operator choice probabilities. We are able to simulate how these probabilities would change if one of the counterfactual scenarios took place. The results are presented in Table 7a and Table 7b for Scenarios 1 and 2, respectively.

The results show that with no excessive off-net price asymmetry against the entrant (Play), the probability with which it would be chosen by consumers (and hence its market share) would increase by 2.8 percentage points in the postpaid segment and by 1.7 percentage points in the prepaid segment. Interestingly, the loss of subscribers would not be equally split among the three incumbents – almost 50% of Play's new postpaid users would come from Plus, whereas 60% of Play's new prepaid users would come from T-Mobile.

If the MTRs and off-net prices were fully symmetric (Scenario 2), Play's market share would increase by even more. The probability of choosing the entrant would increase by 8.5 and 6.1 percentage points in the postpaid and prepaid segments, respectively. This result indicates that implicit loss of an entrant's market share is not only the outcome of the incumbents' strategic motives. The policy of asymmetric MTRs could also contribute to it, despite having a positive effect on revenues in the shorter-term. The fact that widespread asymmetric regulation of MTRs might be costly in the longer-term has largely been overlooked in practical considerations.

[31] We acknowledge that making the incoming calls attribute salient in the experiment raises some concerns about external validity. In real environment subscribers may not care about the price of receiving a call because it is paid by someone else. Ideally, external validation of this result could come from revealed preference studies, but this is impossible in this particular case due to calling-party-pays pricing regime. On the other hand, the literature on attribute non-attendance shows that respondents simply tend to ignore the attributes they do not care about. Moreover, in mobile telecommunications context, consumers care about being reachable while high price of receiving a call reduces the amount of incoming traffic from other networks. This is enough for making an offer less attractive.

[32] We obtain similar results for the prepaid segment (0.53 vs 0.45) but stronger receiver benefits in the postpaid segment (0.48 vs 0.29), compared to his results (table 9). In our specification we control only for incoming calls from other networks. Hence our $\breve{\gamma}_{off}^{off}$ estimates correspond to off-net receiver benefits in his study.

[33] The average off-net price asymmetry between incumbents and the new entrant amounted to 254% in the postpaid segment and 244% in prepaid segment, whereas the average MTR asymmetry in that period was 189%.

Table 6
Prices in baseline and counterfactual scenarios [PLN/minute].

	Postpaid				Prepaid			
	Orange	T-Mobile	Plus	Play	Orange	T-Mobile	Plus	Play
Baseline scenario Actual situation in 2010–2012								
On-net price	0.13	0.18	0.11	0.02	0.07	0.01	0.05	0.01
Off-net price to incumbents	0.24	0.26	0.24	0.18	0.21	0.21	0.27	0.21
Off-net price to entrant	0.60	0.61	0.59	–	0.56	0.52	0.65	–
MTR	0.15	0.15	0.15	0.29	0.15	0.15	0.15	0.29
Scenario 1 Reduced off–net price asymmetry between incumbents and entrant, corresponding to actual MTR asymmetry in 2010–2012								
On-net price	0.13	0.18	0.11	0.02	0.07	0.01	0.05	0.01
Off-net price to incumbents	0.24	0.26	0.24	0.18	0.21	0.21	0.27	0.21
Off-net price to entrant	0.45	0.50	0.46	–	0.39	0.39	0.52	–
MTR	0.15	0.15	0.15	0.29	0.15	0.15	0.15	0.29
Scenario 2 Fully symmetrical MTR and off-net prices								
On-net price	0.13	0.18	0.11	0.02	0.07	0.01	0.05	0.01
Off-net price	0.24	0.26	0.24	0.18	0.21	0.21	0.27	0.21
MTR	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Note: Scenarios represent various combinations of off-net prices charged by incumbents for calls terminated in the entrant's network. Baseline Scenario refers to the actual prices observed in the market, Scenario 1 represents the prices which would reflect MTR asymmetry (incumbents earn the same markup on off-net calls in all directions), Scenario 2 assumes that MTRs to the entrant and incumbents are on the same level and uniform off-net pricing at the level of off-net prices observed for incumbents. Each value in the table refers to a specific price item or a termination rate (indicated by the row label) and a particular operator (indicated by the column label). The data for the baseline scenario is based on the market monitoring provided by Audytel SA. Values of off-net prices for counterfactual scenarios are based on own calculations.

4. Summary and conclusions

In this paper we empirically identify the strength of receiver benefits based on the stated preferences of Polish mobile subscribers, elicited from a discrete choice experiment. Under the calling-party-pays principle, receiver benefits become an economic externality. The operator of the call-originating party gains direct control over the size of receiver benefits enjoyed by the subscribers of rival operators. Theoretical models of network competition with call externalities identify an incentive for strategic overpricing of off-net calls to reduce receiver benefits and hence lower the attractiveness of rival networks (Jeon et al., 2004; Hoernig, 2007; Armstrong and Wright, 2009). This strategic incentive grows with the size of a network and hence is particularly relevant for limiting market entry and creating consumer lock-in. Recognizing the direct impact of off-net prices set by incumbents on the number of calls received from their peers, potential subscribers will be less likely to choose small a network. We confirm these predictions empirically.

We econometrically model mobile phone subscribers' utility functions taking into account termination-based discriminatory tariffs, call and network externalities, switching costs and brand loyalty. We control for call externalities by introducing a price for incoming calls among the attributes of a subscription plan. We show that the level of incoming price negatively affect the probability of choosing a mobile network which implies that receiver benefits affects operator choices of Polish mobile subscribers. The implied receiver benefit parameter (γ) derived from utility coefficients has a magnitude of 0.35–0.53. This parameter is interpreted as a proportion of the caller's benefit from a unit of call. Our results correspond well with the levels postulated by Hurkens and López (2012) and estimates obtained by Rojas (2017).

Historical developments in the Polish market are consistent with the theoretical predictions of models with call externalities, namely the incentive to set high off-net prices by incumbents. Regardless of whether such overpricing behavior is consistent with Nash behavior or explicitly predatory, large price differentials set by incumbents harm the entrants and create lock-in, giving cause for regulatory intervention. In this paper we illustrate what the outcomes of direct price regulation would be for the structure of market shares.

We introduce two counterfactual scenarios with reduced off-net prices from incumbent networks to the late entrant. In the first scenario off-net prices for calls terminated by an entrant would have to be reduced to reflect MTR asymmetry by virtue of a common markup rule. Scenario 2 assumes that MTRs to the entrant and incumbents are on the same level and a common markup rule mandates uniform off-net pricing on the market at the current level of off-net prices to incumbents. We have simulated the effects of both scenarios on changes in the operators' choice probabilities relative to the baseline. This policy exercise shows that the late entrant would experience a rather small market share gain under the first scenario (1.7–2.8) and a more substantial effect under the second (6.1–8.5). Taking the average duration of contractual period, these changes could be effective within a two year period of market competition. Finally, we note that attribute salience and off-equilibrium scenarios may rise some concerns about external validity of the magnitudes of the predicted market share changes.

Our findings have important implications for the regulatory authorities in countries with a calling-party-pays regime. Call externalities have a clear impact on market conduct but represent a regulatory challenge. On the one hand late entrants are clearly vulnerable to strategically overpriced off-net calls from incumbent networks. On the other hand light regulatory intervention may not bring large effects. More radical intervention would require low and symmetric access charges, but this could have potentially adverse impact on late entrant's profitability by reducing its access revenues. Without knowing the traffic response to the reduced off-net prices, this trade-off cannot be resolved. Nevertheless, scenario 2 shows that allowing a prolonged period of asymmetric MTRs could limit the entrant's market share growth. This has been largely overlooked in practical considerations. A bill-and-keep solution has been debated for years but never implemented. Instead MTR levels in the EU have been continuously

Please cite this article as: M. Sobolewski, M. Czajkowski, Receiver benefits and strategic use of call externalities in mobile telephony markets, Information Economics and Policy (2018), https://doi.org/10.1016/j.infoecopol.2018.03.003

Table 7a
Operator choice probability differential (ΔP) between Scenario 1 (no excessive off-net price asymmetry) and the baseline.

		Postpaid					Prepaid				
		Orange subscribes	T-Mobile subscribes	Plus subscribes	Play subscribes	Overall sample	Orange subscribes	T-Mobile subscribes	Plus subscribes	Play subscribes	Overall sample
Orange	ΔP	1.34***	0.64***	0.52***	0.77***	0.82***	0.11	0.17***	0.14**	0.32***	0.16**
	s.e.	(0.21)	(0.12)	(0.09)	(0.14)	(0.13)	(0.11)	(0.07)	(0.07)	(0.08)	(0.08)
	95% c.i.	(0.96;1.78)	(0.43;0.91)	(0.36;0.72)	(0.55;1.10)	(0.59;1.11)	(−0.10;0.34)	(0.05;0.32)	(0.01;0.28)	(0.17;0.50)	(0.02;0.33)
T-Mobile	ΔP	0.36***	1.10***	0.34***	0.48***	0.58***	1.07***	1.01***	0.93***	1.57***	1.09***
	s.e.	(0.05)	(0.13)	(0.05)	(0.07)	(0.06)	(0.14)	(0.18)	(0.15)	(0.19)	(0.15)
	95% c.i.	(0.28;0.46)	(0.87;1.38)	(0.26;0.44)	(0.36;0.62)	(0.47;0.71)	(0.79;1.36)	(0.65;1.37)	(0.64;1.24)	(1.24;1.95)	(0.80;1.4)
Plus	ΔP	1.08***	1.32***	1.86***	1.42***	1.43***	0.40***	0.37***	0.64***	0.52***	0.47***
	s.e.	(0.14)	(0.17)	(0.23)	(0.19)	(0.17)	(0.06)	(0.05)	(0.09)	(0.08)	(0.06)
	95% c.i.	(0.83;1.37)	(1.01;1.69)	(1.45;2.35)	(1.07;1.83)	(1.12;1.8)	(0.31;0.52)	(0.28;0.49)	(0.47;0.83)	(0.39;0.69)	(0.36;0.61)
Play	ΔP	−2.77***	−3.06***	−2.72***	−2.67***	−2.83***	−1.58***	−1.56***	−1.70***	−2.42***	−1.72***
	s.e.	(0.32)	(0.36)	(0.31)	(0.31)	(0.32)	(0.27)	(0.26)	(0.27)	(0.30)	(0.26)
	95% c.i.	(−3.45;−2.20)	(−3.82;−2.43)	(−3.38;−2.16)	(−3.36;−2.14)	(−3.51;−2.26)	(−2.14;−1.09)	(−2.10;−1.08)	(−2.27;−1.20)	(−3.05;−1.89)	(−2.28;−1.24)

Table 7b
Operator choice probability differential (ΔP) between Scenario 2 (fully symmetrical MTRs and off-net prices) and the baseline.

		Postpaid					Prepaid				
		Orange subscribes	T-Mobile subscribes	Plus subscribes	Play subscribes	Overall sample	Orange subscribes	T-Mobile subscribes	Plus subscribes	Play subscribes	Overall sample
Orange	ΔP	4.78***	2.15***	1.70***	2.13***	2.77***	1.66***	1.16***	1.16***	1.45***	1.35***
	s.e.	(0.64)	(0.35)	(0.28)	(0.36)	(0.38)	(0.34)	(0.22)	(0.22)	(0.25)	(0.25)
	95% c.i.	(3.68;6.18)	(1.55;2.93)	(1.22;2.3)	(1.54;2.93)	(2.12;3.61)	(1.04;2.37)	(0.77;1.63)	(0.77;1.62)	(1.00;1.98)	(0.90;1.88)
T-Mobile	ΔP	0.99***	3.25***	0.94***	1.22***	1.65***	3.55***	3.7***	3.68***	4.91***	3.82***
	s.e.	(0.17)	(0.41)	(0.17)	(0.21)	(0.20)	(0.54)	(0.61)	(0.56)	(0.60)	(0.54)
	95% c.i.	(0.7;1.36)	(2.54;4.14)	(0.66;1.31)	(0.85;1.69)	(1.29;2.08)	(2.53;4.64)	(2.46;4.9)	(2.63;4.8)	(3.81;6.16)	(2.81;4.95)
Plus	ΔP	2.93***	3.63***	5.87***	3.38***	4.10***	0.81***	0.79***	1.19***	1.13***	0.95***
	s.e.	(0.42)	(0.48)	(0.68)	(0.52)	(0.49)	(0.17)	(0.17)	(0.29)	(0.21)	(0.19)
	95% c.i.	(2.19;3.81)	(2.76;4.65)	(4.67;7.35)	(2.46;4.49)	(3.23;5.14)	(0.52;1.17)	(0.50;1.15)	(0.67;1.79)	(0.76;1.58)	(0.60;1.35)
Play	ΔP	−8.70***	−9.03***	−8.51***	−6.73***	−8.53***	−6.02***	−5.66***	−6.03***	−7.48***	−6.12***
	s.e.	(0.92)	(0.99)	(0.90)	(0.84)	(0.90)	(0.88)	(0.84)	(0.89)	(0.85)	(0.85)
	95% c.i.	(−10.66;−7.06)	(−11.17;−7.3)	(−10.43;−6.91)	(−8.54;−5.23)	(−10.48;−6.93)	(−7.82;−4.39)	(−7.38;−4.06)	(−7.88;−4.37)	(−9.29;−5.93)	(−7.89;−4.56)

Notes: ***, ** and * indicate 1% and 5% significance levels, respectively. ΔP represents the change in the mean probability of choosing an operator (row) by respondents who were subscribed to a particular operator (column), between the Baseline Scenario (actual prices observed in the market) and Scenario 1 (the prices which would reflect MTR asymmetry, incumbents earn the same markup on off-net calls in all directions) or Scenario 2 (MTRs to the entrant and incumbents are on the same level, uniform off-net pricing at the level of off-net prices observed for incumbents). Estimates of ΔP in each column sum up to zero (the decrease in the probability of choosing Play is compensated by the increase in the probability of choosing incumbent operators). The estimates, standard errors and 95% confidence intervals were simulated (parametrically bootstrapped).

pushed down with falling marginal termination cost. Since January 2016 they are below 1 euro cent per minute in most European countries (BEREC, 2016), incentivizing operators to withdraw from termination-based price discrimination. Despite recent developments, the problem of strategic off-net/on-net price differentials driven by call externalities lasted for many years and could weaken post-entry competition.

Acknowledgments

We are grateful to Lukasz Grzybowski and two anonymous referees for extensive comments on the earlier versions of the paper and also to the audiences of 27th European ITS Conference in Cambridge, 9th ICT Paris Conference at Telecom ParisTech and the 5th International Choice Modeling Conference in Cape Town for their feedback on earlier versions of this paper. We acknowledge the permission from AUDYTEL S.A, a private sector consultancy, to reuse the data for the purpose of this paper. The survey of Polish mobile phone users was originally commissioned for the purposes of an advisory study on the reasons for off-net calls asymmetry. The study was conducted for P4 mobile network operator in 2016. Both authors took part in this study as external consultants and were responsible for designing a survey and modeling discrete choice data.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.infoecopol.2018.03.003.

References

Armstrong, M., Wright, J., 2009. Mobile call termination in the UK: a competitive bottleneck? Cases in European Competition Policy: The Economic Analysis. CUP, Cambridge.
BEREC, 2016. Termination rates at European level. January 2016. BEREC.
Calzada, J., Valletti, T.M., 2008. Network competition and entry deterrence*. Econ. J. 118 (531), 1223–1244.
Carson, R.T., Czajkowski, M., 2014. The discrete choice experiment approach to environmental contingent valuation. In: Hess, S., Daly, A. (Eds.), Handbook of Choice Modelling. Edward Elgar, Northampton, MA.
Corrocher, N., Zirulia, L., 2009. Me and you and everyone we know: an empirical analysis of local network effects in mobile communications. Telecommun. Policy 33 (1), 68–79.
Czajkowski, M., Budziński, W., 2016. Choice task blocking and design efficiency. Paper presented at the 5'th Workshop on Discrete Choice Modelling available from http://czaj.org/pub/presentations/Czajkowski_2016-10-06b.pdf .
Czajkowski, M., Sobolewski, M., 2011. Measuring network effects in mobile telecommunications markets with stated-preference valuation methods. Int. J. Manage. Netw. Econ. 2 (2), 197–215.
Czajkowski, M., Sobolewski, M., 2016. How much do switching costs and local network effects contribute to consumer lock-in in mobile telephony? Telecommun. Policy 40 (9), 855–869.
DeGraba, P., 2003. Efficient intercarrier compensation for competing networks when customers share the value of a call. J. Econ. Manage. Strategy 12 (2), 207–230.
ERG, 2008. Common Position on symmetry of fixed call termination rates and symmetry of mobile call termination rates.
European Commission, 2009. Explanatory note to commission recommondation on the regulatory treatment of fixed and mobile termination rates in the EU. SEC(2009) 600.
Ferrini, S., Scarpa, R., 2007. Designs with a priori information for nonmarket valuation with choice experiments: a Monte Carlo study. J. Environ. Econ. Manage. 53 (3), 342–363.
Grzybowski, L., Pereira, P., 2011. Subscription choices and switching costs in mobile telephony. Rev. Ind. Organ. 38 (1), 23–42.
Harbord, D., Hoernig, S., 2015. Welfare analysis of regulating mobile termination rates in the UK. J. Ind. Econ. 63 (4), 673–703.
Harbord, D., Pagnozzi, M., 2010. Network-based price discrimination and Bill-and–Keep' vs. cost-based'regulation of mobile termination rates. Rev. Netw. Econ. 9 (1).
Hensher, D.A., Rose, J.M., Greene, W.H., 2015. Applied Choice Analysis, 2 Ed. Cambridge University Press, Cambridge, UK.
Hermalin, B.E., Katz, M.L., 2004. Sender or receiver: who should pay to exchange an electronic message? RAND J. Econ. 423–448.
Hermalin, B.E., Katz, M.L., 2006. Customer or complementor? Intercarrier compensation with two-sided benefits. Competition Policy Center.
Hoernig, S., 2007. On-net and off-net pricing on asymmetric telecommunications networks. Inf. Econ. Policy 19 (2), 171–188.
Hoernig, S., 2014. Competition between multiple asymmetric networks: theory and applications. Int. J. Ind Organ. 32, 57–69.
Hurkens, S., López, Á.L., 2012. The welfare effects of mobile termination rate regulation in asymmetric oligopolies: the case of Spain. Telecommun. Policy 36 (5), 369–381.
Jeon, D.-S., Laffont, J.-J., Tirole, J., 2004. On the receiver-pays principle. RAND J. Econ. 85–110.
Littlechild, S.C., 2006. Mobile termination charges: calling party pays versus receiving party pays. Telecommun. Policy 30 (5), 242–277.
Louviere, J.J., Hensher, D.A., Swait, J.D., 2006. Stated Choice Methods: Analysis and Applications. Cambridge University Press, Cambridge.
López, Á.L., Rey, P., 2016. Foreclosing competition through high access charges and price discrimination. J. Ind. Econ. 64 (3), 436–465.
Maicas, J.P., Polo, Y., Javier Sese, F., 2009a. Reducing the level of switching costs in mobile communications: The case of Mobile Number Portability. Telecommun. Policy 33 (9), 544–554.
Maicas, J.P., Polo, Y., Sese, F.J., 2009b. The role of (personal) network effects and switching costs in determining mobile users' choice. J. Inf. Technol. 24 (2), 160–171.
Manski, C.F., 1977. The structure of random utility models. Theory Decis. 8 (3), 229–254.
McFadden, D., 1974. Conditional logit analysis of qualititative choice behaviour. In: Zarembka, P. (Ed.), Frontiers in Econometrics. Academic Press, New York, NY, pp. 105–142.
Rojas, C., 2017. How much is an incoming message worth? Estimating the call externality. Inf. Econ. Policy 38, 23–37.
Sandbach, J., van Hooft, L., 2010. Using On-net/Off-net Price Differential to Measure the Size of Call Externalities and Its Implications For Setting Efficient Mobile Termination Rates. Edward Elgar Publishing.
Scarpa, R., Rose, J.M., 2008. Design efficiency for non-market valuation with choice modelling: how to measure it, what to report and why. Aust. J. Agric. Resour. Econ. 52 (3), 253–282.
Sobolewski, M., Czajkowski, M., 2012. Network effects and preference heterogeneity in the case of mobile telecommunications markets. Telecommun. Policy 36 (3), 197–211.
Train, K.E., 2009. Discrete Choice Methods With Simulation. Cambridge University Press, New York.
UKE, 2016a. Porównanie nasycenia rynku usługami telefonii ruchomej w Polsce (eng: Comparison of penetration measures of mobile telephony in Poland). Office of Electronic Communications, Warsaw.
UKE, 2016b. Raport o Stanie Rynku Telekomunikacyjnego w Polsce w 2016 roku (eng: Report on Telecommunications Market in Poland in 2016). Office of Electronic Communications, Warsaw.