Entry on market with switching costs and network effects. How long does it take to catch-up with incumbents when consumers are heterogeneous?

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***** Preliminary version.[4] *****

ABSTRACT

Empirical evidence from post entry competition shows that it mayt take considerable amount of time before the entrant eventually catches up with incumbents. In this paper we report preliminary results from our study on factors determining the scale of market entry when switching costs and network effects are present in the market and subscribers are heterogeneous with respect to them. We propose methodological approach which builds on two novel elements: (i) introducing customer heterogeneity in form of parametric random distributions of individual utility function parameters and (ii) creating and implementing simulation model of dynamic switching behavior induced by changing magnitudes of network effects. We calibrate our model with data from empirical preference study of polish mobile phone users and study evolution of market structure of polish mobile telecommunications for different characteristics of consumers, pricing strategies of firms and regulatory policies.

Our results point that post-entry market structure heavily depends on how switching costs and network effects are distributed across subscribers. It will not always be possible for the new entrant to catch-up with incumbents in terms of equal market shares. The entrant gains larger market share when heterogeneity of switching costs is high. Another critical factor are levels of off-net rates set by new entrant to mitigate the network effects in incumbent networks and initial concentration of network effects in incumbent networks. In our simulations long term market share of new entrant varied from 5% to even 40% depending on new entrant's pricing, concentration of switching cost and a scale of heterogeneity. Heterogeneity of switching cost occurred to be the most important determinant of the scale of entry in our simulations.

KEYWORDS

Market entry, switching costs, network effects, mobile telecommunications, preference heterogeneity, monte carlo simulation.

JEL CLASSIFICATION

L1; L86; O3

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1 INTRODUCTION

Switching costs and network effects attract a lot of attention in empirical research oriented towards regulatory policy especially in telecommunications and markets for electronic services such as social networking or internet. It is well documented in the literature that network effects and switching costs can be strategically used to weaken market competition and perhaps even deter entry by securing market power of incumbents

In this paper we take a closer look on how switching costs and network effects impact market entry and dynamics of post entry competition when markets are saturated. The main rationale for adopting dynamic perspective comes from striking observation of telecommunications markets. For example in Poland new entrant (Play) after seven years of post-entry competition has 19,5% market share – much below average for three incumbents (see Figure 1). This observation points to some kind of persistent advantage of incumbents over new entrant who has significantly lower market share then incumbent operators even after several years of post entry competition. While textbook intuition for homogenous products would rather suggest equal market shares in long term equilibrium, empirical reality rises concerns about the competitiveness of the industry in the short run. For example, insufficient incentives for entry will have important negative implications for the outcomes of spectrum auctions and the speed of technological progress preserving concentrated and less competitive oligopoly

The main objective of the present paper is to show that scale of market entry under assumption tht it is largely driven by customer heterogeneity with respect to network effects and switching costs. The novelty of our approach builds on: (1) introducing customer heterogeneity with respect to network effects in form of parametric random distributions and (2) creating dynamic simulation model of switching behavior which will allows us to model post-entry market structure for different characteristics of heterogeneity, pricing strategies of firms and regulatory policies.

As a context of our analysis we take mobile telephony which is characterized by large switching costs and network effects. We calibrate our model with empirical data on heterogeneity of switching costs and network effects estimated for polish mobile phone users to increase validity of our simulations. We want to see how the entry of the fourth mobile operator (PLAY) is sensitive to different magnitudes of heterogeneity and pricing of incumbents. More specifically, we implement simulation framework in order to answer three research questions:

- Will new entrant always be able to catch-up with incumbents in terms of market shares?
- Which variables remaining under control of incumbents and entrant – such as for instance pricing - affect the speed of this catching-up process?
- Which policy measures might be implemented to facilitate market entry on market with switching costs?

Figure 1. Market shares evolution in Poland mobile telecommunications.
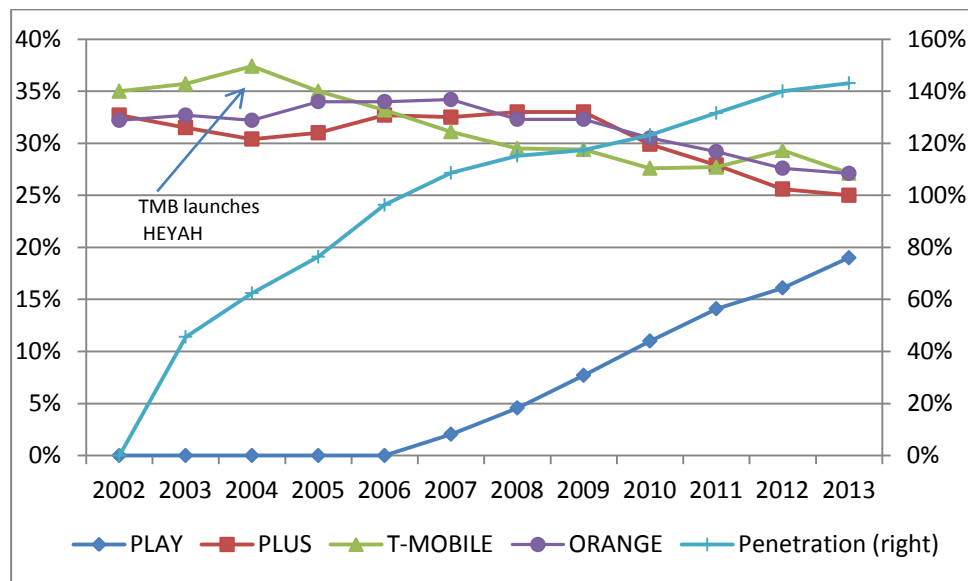
source: Annual reviews of telecommunication markets in Poland provided by Office of Communications (UKE) link: www.uke.gov.pl

2 LITERATURE

There is a consensus inliterature that entry on markets with high barriers to mobility is difficult. An entrant must provide sufficiently large incentives to attract consumers because they face substantial costs when changing provider (Farrell and Klemperer 2007). Switching costs take the form of either direct payments such as penalty fees for terminating contract, forgone benefits or non-monetary items such transaction cost or searching costs. If those barriers to switching providers are high, new entrant will find it too costly to undercut price offered by incumbent to induce switching, thus ending in small scale market share (Klemperer 1987).[5] Succesfull entry is even more difficult if switching costs are accompanied by network effects, which constitute yet another barrier to mobility across providers. The impact of switching costs and network effects on entry is in principle similar as both create so called lock-in effects (Klemperer 1987). If network externalities are strong enough market structure can even evolve towards corner equilibrium with winner-takes-all outcome (Economides 1996).

An example of network effects in mobile telephony is a situation when a given person has large share of her frequently called friends and family in the same network. This situation creates additional benefits from on-net rebates offered by incumbent. This type of network effects are called micro externalities and play an important role in locking-in subscribers with

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[5] A popular example of switching cost in mobile communications which greatly weakened intensity of market competition was lack of mobile number portability.

existing providers (Sobolewski and Czajkowski 2012), (Corrocher and Zirulia 2009), (Maicas, Polo et al. 2009).

Recently growing attention is put into studying the role those phenomena play in building up first mover advantage and foreclosing market. The latter issue is of great importance on markets with rapid technological change, where entry brings larger welfare enhancement through innovations. It is well documented in the literature that network effects and switching costs can be strategically used to weaken market competition and perhaps even deter entry by securing market power of incumbents (Calzada and Valletti 2008), (Kim and Kwon 2003). The first mover advantage created by those barriers to mobility, might lead to lower performance of markets in both static (prices) and dynamic (innovation) dimension, leading to outcomes with reduced welfare. Those conclusions are widely supported by empirical evidence from telecommunication markets where even after few years of post-entry competition the entrant has much lower market share (Bijwaard, Janssen et al. 2008).

Majority of the papers studying market entry assume that all customers are homogeneous with respect to switching costs and network effects. These simplifying assumptions do not allow to model consumer switching behavior in detail and thus limit also conclusions about the expected scale of entry on the market. Recent contributions recognize this limitation and introduce heterogeneity of preferences. This allows to differentiate between the core customers who are very loyal to the current provider and also the group who might switch first to the new entrant. Their departure will weaken the gravity of network effect in incumbent network and induce more consumers to switch in subsequent periods, introducing interesting dynamics to the evolution of market structure. This dynamic switching mechanism induced by changing magnitudes of network effects is the fundamental idea of our study and provides rationale for accounting for consumers heterogeneity when studying market entry. We want explore our idea in a series of policy-relevant simulations which will analyze the scale of market share development of new entrant.

3 MODELLING FRAMEWORK

Our methodology of simulating evolution of post-entry market structure uses two novel elements. First, we adopt empirical approach, based on random parameter logit model, to capture heterogeneity of consumer preferences with respect to individual mobility barriers. Secondly, we develop simulation framework, which introduces dynamic algorithm for switching induced by changing magnitudes of network effects. We use this framework to smulate how market entry is affected by (i) pricing of new entrant, (ii) concentration of initial network effect in incumbent networks and (iii) changes into the standard deviations of those empirical distributions.

3.1 EMPIRICAL APPROACH

We utilize dataset obtained from survey designed to model preferences for mobile operators choice in Poland and utilized originally in a study by (Sobolewski and Czajkowski 2013). For the purposes of present study we have assumed a slightly different specification of utility function in order to facilitate analysis of switching behavior. Within the proposed

utility function subscribers are exposed to mobility barriers when choosing whether to continue with the incumbent or switch to the new operator. More specifically, utility of subscriber "i" who decided either to stay with his present incumbent operator (OP=I) or to switch to new entrant (OP=E) takes the form of:

$$u_i^{OP} = \beta_{1,i} \cdot SQ + \beta_{2,i} \cdot p_{on}^{OP} \cdot FF_i^{OP} + \beta_{3,i} \cdot p_{off}^{OP}\left(1 - FF_i^{OP}\right) + \epsilon_i, \tag{1}$$

where:

- SQ is a dummy variable ("SQ=1" if customer decides to stay with his current incumbent provider and "SQ=0" if he decides to switch to new entrant). Parameter value for SQ measures the strength of status quo inertia which is primary type of switching cost assumed in the model.

- FF_i^{OP} denotes present concentration of network effects – that is current percentage share of family and friends group (hence FF) of person "i" in the selected operator's network. Parameter value for FF indicates the strength of local network effects.

- p_{on}^{OP} and p_{off}^{OP} are on-net and off-net prices set by selected operator, which interact with local network effects indicating strength of network effect with (a) increasing of FF share in the same network and (b) with increasing rebates for on-net calls offered by the current operator.

$\beta_{1,i}$; $\beta_{2,i}$; $\beta_{3,i}$ are individual specific parameters assumed to be distributed normal.

Although each consumer has specified and stable parameters of the utility function, the parameters may have a specific distribution in the consumers' population reflecting their preference (taste) heterogeneity. This study has accounted for preference heterogeneity by using random parameters logit (RPL) framework (Train 2009). In the RPL model, the parameters of the utility function are random variables following a priori specified distributions. This treatment allows for improvement of model fit compared to standard multinomial logit (Greene 2011). We have obtained distributions of utility function parameters which correspond to relevant choice attributes: (i) on-net and (ii) off-net prices interacted with local network effects and (iii) status quo inertia which measures the level of switching costs in the market. The estimation results are summarized in Table 2.

Table 2. Estimation results of equation (1). Random parameter logit.

	means			standard deviation		
variable	b	s.e.	p-value	b	s.e.	p-value
SQ	1,3015	0,1760	0,0000	2,0193	0,0716	0,0000
(1-FF)*P_OFF	-4,6228	0,4644	0,0000	-2,8316	0,3049	0,0000
(1-OTH)*P_OFF	-2,4276	0,4106	0,0000	-1,9129	0,3033	0,0000
FF*P_ON	-3,4775	0,5671	0,0000	-2,8685	0,4134	0,0000
OTH*P_ON	-4,9808	0,6298	0,0000	4,5600	0,4154	0,0000

Estimation results indicate that there is considerable level of customer heterogeneity with respect to switching costs (SQ). For example, consumers on average assign positive (1.3) value to staying with their current provider, although there is 26% of subscribers in the left

tail of SQ distribution who assign negative value to staying with their current provider. Those are highly dissatisfied subscribers who will be willing to switch to the new entrant even in the absence of other incentives. Their departure will weaken the gravity of network effect in incumbent network and induce more consumers (with higher values of β_2) to switch in the next period. This dynamic switching mechanism induced by changing magnitudes of network effects is the main force which drives evolution of market structure in post entry period.

Our specification of utility functions indicates that local network effects are significant for consumers when deciding about the operator choice, although subscribers are again heterogeneous with respect to the strength of this effect. The comparison of parameter values for $p_{on}^{OP} \cdot FF_i^{OP}$ and $p_{off}^{OP}(1 - FF_i^{OP})$ indicates that on average the utility loss from calling family and friends within the same network is smaller than if these are off-net calls. Thus an operator who managed to attract a large part of someone's social network gains additional market power over this subscriber.

3.2 SIMULATION FRAMEWORK

The simulation environment has been built in R-Studio. It is based on iterative procedure which counts how many subscribers decided to switch from incumbent operators in subsequent periods based on utility comparisons. The algorithm implements the idea of dynamic switching mechanism induced by changing magnitudes of network effects as described above. Below we present several details which explan how our simulator works:

1. Market structure: Prior to entry there is a symmetric triopoly with 3 incumbents (OP = A, B, C) having equal market shares, all setting identical prices for respectively off-net and on-net calls.

2. Full market saturation. There are no unsubscribed customers left prior to entry. Subscribers are identically normally distributed across incumbents with respect to switching costs and network effects. The distributions characterize the magnitude of subscribers heterogeneity. Empirical distributions are derived with RPL estimation of equation (1) on dataset from preference survey. Results of estimation yield the following statistically significant parameter values: $\beta_1 \sim N[1.3, 2.01]$, $\beta_2 \sim N[-3.47, 2.86]$, $\beta_3 \sim N[-4.62, 2.8]$.

3. Pricing strategy of new entrant: New entrant (OP=D) has no choice but to encourage switching. A part of such strategy is to set an off-net price for his customers at a level close to the on-net prices of incumbents to mitigate the effect of local network effect. As a result customers of new entrant will have similar cost of calling their family and friends (FF) who stayed in incumbent's network as they had before switching. In our simulations we set $p_{off}^D = a \cdot p_{on}^{A,B,C}$ where $a = (1; \frac{3}{2}; 2; \frac{5}{2})$ which corresponds either to full mitigation ($a = 1$) or partial mitigation ($a > 1$). Another element of entrant's mitigation strategy is to offer low on-net price to induce building local network effects in his own network. We set this price to zero: $p_{on}^D = 0$

4. Pricing strategy of incumbents: Incumbent firms will set higher prices to exploit their locked-in customers. In our simulations we set those prices on the empirical levels obtained in the survey: $p_{on}^{A,B,C} = 0,2$ and $p_{off}^{A,B,C} = 0,5$.

5. Switching mechanism. Switching occurs if some subscribers obtain greater utility from changing operator, compared to utility from staying with the same provider. More specifically, denote by u_i^{A,T_k} utility of consumer 'i' from tariff plan offered by operator A at time period T_k and by u_i^{D,T_k} respective utility of that consumer from plan offered by operator D. Switching mechanism will determine those subscribers who are willing to change operator in a given period based on utility comparison. Let us assume that in period T_k, person 'i" is subscriber to operator A. Then based on utility equation given above $u_i^{A,T\_k} = \beta_{1,i} \cdot SQ + \beta_{2,i} \cdot p_{on}^A \cdot FF_i^{A,T\_k} + \beta_{3,i} \cdot p_{off}^A (1 - FF_i^{A,T\_k})$, where SQ=1 and FF_i^{A,T_k} is the current share of FF group in network A, individual specific parameters $\beta_{k,i}$ are drawn from assumed normal distributions and p_{on}^A, p_{off}^A are prices set by incumbent. On the other hand if that subscriber considers to switch from operator A to new entrant D, then his utility is equal to $u_i^{D,T\_k} = \beta_{1,i} \cdot SQ + \beta_{2,i} \cdot p_{on}^D \cdot FF_i^{D,T\_k} + \beta_{3i} \cdot p_{off}^D (1 - FF_i^{D,T\_k})$, where SQ=0 and FF_i^{D,T_k} is the current share of FF group in network D. By setting those two utilities equal, we obtain a hyper plane of indifference which divides subscribers' space into switchers and non-switchers in a given period. In our simulations we have used different values of initial FF concentration in incumbent networks: $FF^{A,B,C} = (0,4; 0,95)$

6. Dynamics of post-entry market development. The crucial element in evaluation of utilities is the way in which the share of FF in the same network evolves over time, inducing more switching in the following periods. In the first period after entry: T_1, operator D has zero customers, so he will attract only those subscribers who have negative values of parameters related to SQ (indicating most upset subscribers) and low value for FF. In this case utility from switching simplifies to $u_i^{D,T\_1} = \beta_{3,i} \cdot p_{off}^D (1 - 0)$, and the utility from staying with operator A will be u_i^{A,T_1}, as given above evaluated at initial level of network effect concentration in incumbent network FF_i^{A,T_1}. Assume that based on utility comparison in T_1, at the end of period T_1, $s_1\%$ of subscribers belonging to one's FF^A group has switched to D. This implies that in T_2 the share of FF_i^{A,T_2} will be smaller and the share of FF_i^{D,T_2} will be larger inducing more subscribers to switch. The same kind of recurrent procedure allows to simulate the market development in successive periods.

7. Structure of network effects. We assume that social networks do not overlap and have equal size. This is strong assumption but it greatly simplifies the impact analysis of local network effects – we do not need to account for how local networks are interrelated.[6]

8. No switching among incumbents. We rule out possibility of switching among incumbents and also switching back from new entrant.

Having established this environment we are able to model the evolution of post entry market structure in response to the number of factors related to consumer characteristics, prices and

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[6] This assumption rules out situations in which person X is a friend of Y and Z, but Y and Z do not consider themselves as friends. In other words, we assume a case when friendship is a fully transitive relation implying that all individuals have exactly the same group of friends. While this is strong assumption, it makes our simulations tractable.

regulatory policy measures – such as introduction of number or service portability. In the next section we show our preliminary results of modeling three effects on entry:

- level of initial concentration of FF in incumbent networks (we expect this parameter to lower the market share of new entrant),
- level of off-net prices set by new entrant to compete against the on-net rate of incumbent (we expect that lower pricing of new entrant will increase his market share).
- magnitude of SQ heterogeneity as set by standard deviation of its distribution in subscibers' population (we expect positive impact of heterogeneity on market share).

4 RESULTS

We report our results with a series of graphs which show the evolution of market share of new entrant in the 5th period after entry, for high and low heterogeneity of switching cost (SQ). In most of our simulations after 5 periods new entrant's market share reaches stability. For each simulation we provide values for parameters of utility function which were held constant to meet ceteris paribus condition and indicate by red 'x' manipulated parameter (i.e the one which value changed). No correlation was assumed between distributions of β_1; β_2; β_3.

4.1 INITIAL CONCENTRATION OF FF IN INCUMBENT NETWORKS

In this simulation we changed the level of $FF^{A,B,C}$ from 40% to 95% by 5 percentage points increments, holding constant prices and level of heterogeneity (see Figure 3). We start from higher level of SQ heterogeneity: $\beta_1 \sim N[1.3, 2.01]$.

- $p_{on}^D = 0; p_{off}^D = 0{,}2; p_{on}^{A,B,C} = 0{,}2; p_{off}^{A,B,C} = 0{,}5; FF^{A,B,C} = x$
- $\beta_1 \sim N[1.3, 2.01], \beta_2 \sim N[-3.47, 2.86], \beta_3 \sim N[-4.62, 2.8].$

Fig. 3. Impact of FF concentration on new entrant market share for <u>high</u> heterogeneity of switching cost.
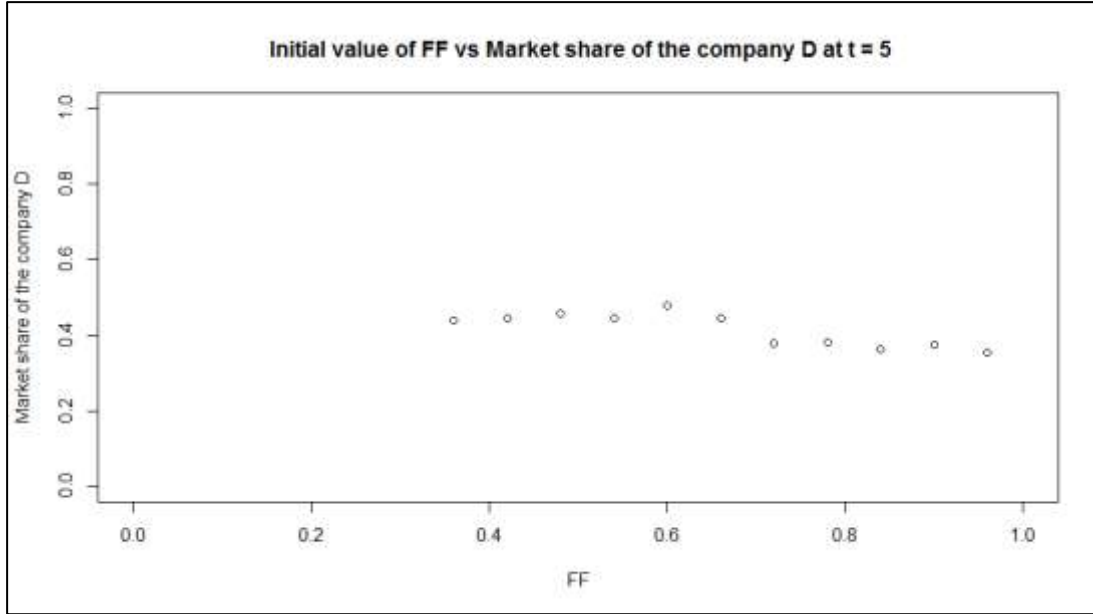
Initial value of FF vs Market share of the company D at t = 5

In the second series of simulation we reduced standard deviation of SQ from $\beta_1 \sim N[1.3, 2.01]$ to $\beta_1 \sim N[1.3, 1.0]$ to introduce lower heterogeneity of switching costs and again simulated the impact of initial FF concentration in incumbent networks (see Figure 4).

- $p_{on}^D = 0; p_{off}^D = 0{,}2; p_{on}^{A,B,C} = 0{,}2; p_{off}^{A,B,C} = 0{,}5; FF^{A,B,C} = x$
- $\beta_1 \sim N[1.3, 1.0], \beta_2 \sim N[-3.47, 2.86], \beta_3 \sim N[-4.62, 2.8]$.

Fig. 4. Impact of FF concentration on new entrant market share for <u>low</u> heterogeneity of switching cost.

Initial value of FF vs Market share of the company D at t = 5
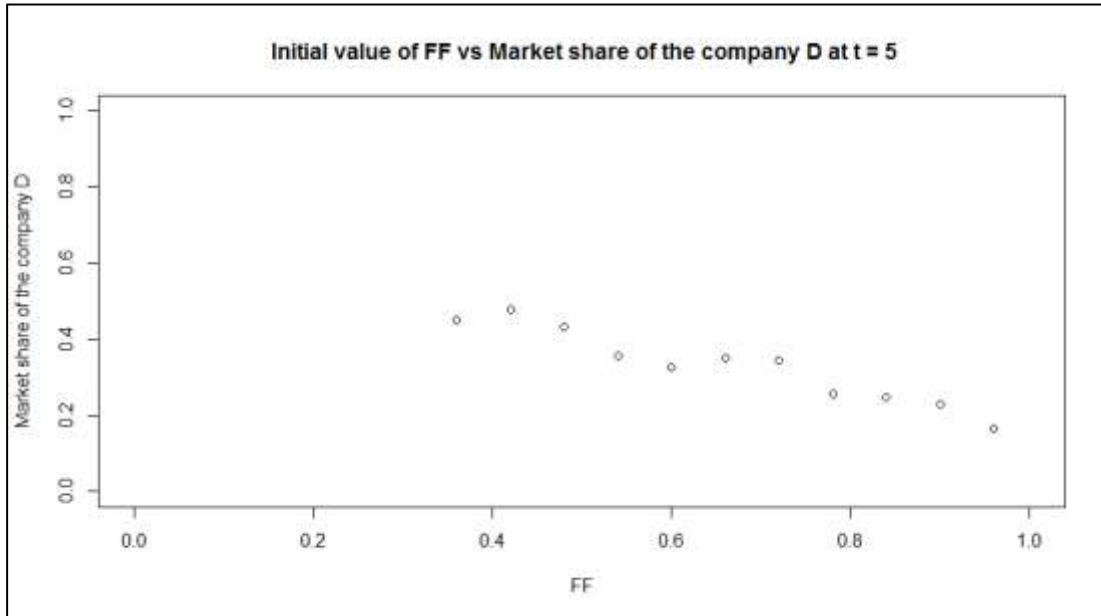
Clearly with lower heterogeneity of switching costs, market share of new entrant starts to be sensitive to initial concentration of network effect in incumbent networks. In the latter case, the greter the concentration of FF in incumbent network the smaller the market share gained by new entrant.

4.2 NEW ENTRANT PRICING

In this simulation we changed the level of new entrant off-net price p_{off}^D from 0,2 to 0,6 by 0,05 increments, holding constant other prices, level of heterogeneity and initial concentration of FF (see Figure 5). We start again with higher heterogeneity of SQ.

- $p_{on}^D = 0; p_{off}^D = x; p_{on}^{A,B,C} = 0,2; p_{off}^{A,B,C} = 0,5; FF^{A,B,C} = 0.6$
- $\beta_1 \sim N[1.3, 2.01], \beta_2 \sim N[-3.47, 2.86], \beta_3 \sim N[-4.62, 2.8]$.

Fig. 5. Impact of new entrant off-net pricing on his market share for <u>high</u> heterogeneity of switching cost.
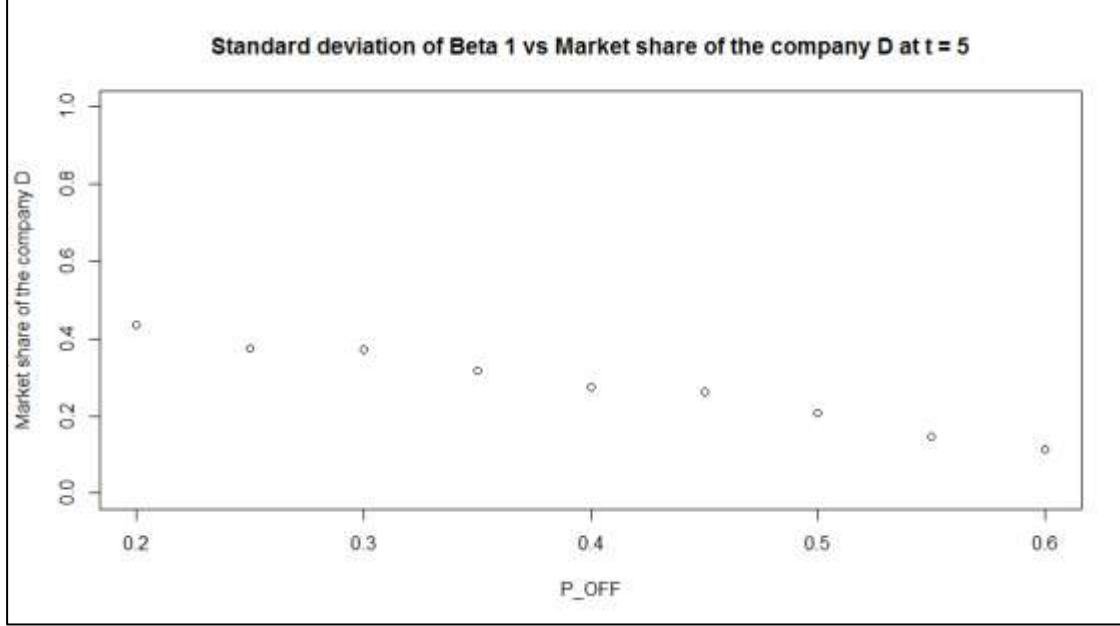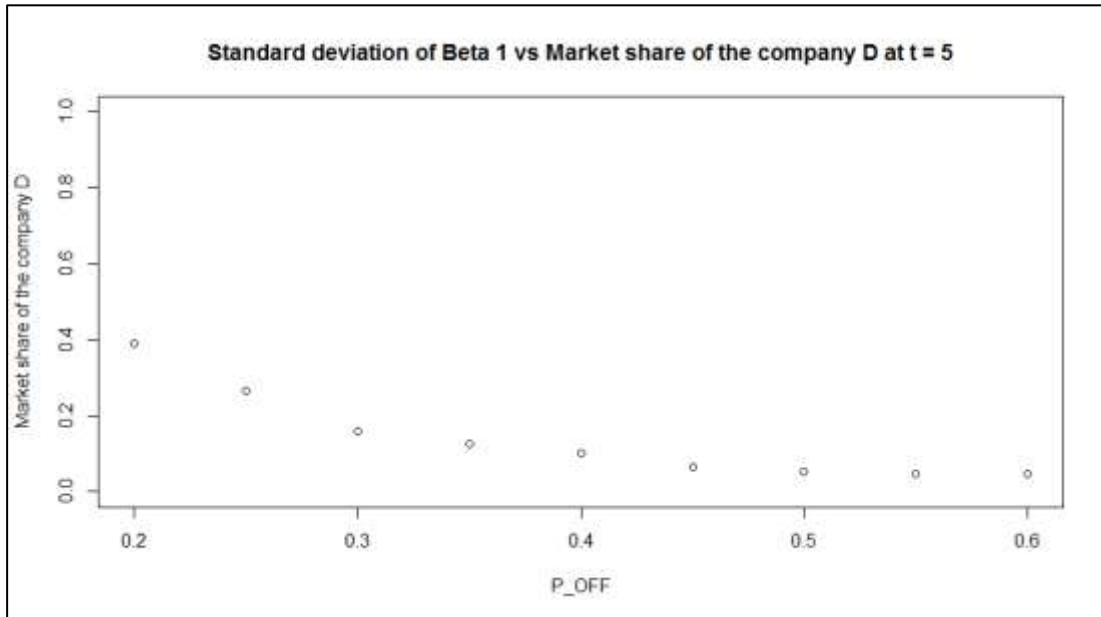

Fig. 6. Impact of new entrant off-net pricing on his market share for <u>low</u> heterogeneity of switching cost.

In the second series of simulation we reduced standard deviation of SQ from $\beta_1 \sim N[1.3, 2.01]$ to $\beta_1 \sim N[1.3, 1.0]$ to introduce lower heterogeneity of switching costs and again simulated the impact of off-net price set by new entrant (see Figure 6).

- $p_{on}^D = 0; p_{off}^D = x; p_{on}^{A,B,C} = 0,2; p_{off}^{A,B,C} = 0,5; FF^{A,B,C} = 0.6$
- $\beta_1 \sim N[1.3, 1.0], \beta_2 \sim N[-3.47, 2.86], \beta_3 \sim N[-4.62, 2.8].$

Under full mitigation, when new entrant sets off-net price at 0,20 pln per minute that is at the same level as on-net prices of incumbents, his market share is dominant (40%) regardless of low/high heterogeneity with respect to switching costs. However If an entrant is not able to fully outweight network externalities offered by incumbent operators then the level of switching costs heterogeneity agains starts to play an important role in determination of new entrant market share.

5 CONCLUSIONS AND DISCUSSION

In this study we have implemented simulation model to study the evolution of market share of new entrant in the presence of switching costs and network effects. Our model builds on dynamic switching mechanism induced by changing magnitudes of network effects. In each iteration the number of switching subscribers is calculated based on comparison of utility function. We have tested for the role of initial concentration of family and friends in the incumbent networks as well as the level of off-net price set by new entrant against on-net pricing by incumbents. We have evaluated the impact of both effects for high and low heterogeneity of switching costs, taking empirical estimates for distribution parameters from the discrete choice experiment conducted on polish mobile subscribers.

Our results indicate that the level of off-net price set by new entrant and initial concentration of family and friends in incumbent networks can be important determinants of new entrant market prospects. However both impacts are conditional on the level of switching costs heterogeneity. In fact the heterogeneity of switching costs occurred to be very influential determinant of new entrant market share. Increasing heterogeneity corresponds to thicker tails of SQ distribution, reflecting how large is the group of consumers who are very much dissatisfied with their current operators. The larger this group is the less costly the entry will be in terms of new entrant pricing required to gain sufficient market share or the more unfavorable conditions with respect to initial concentration of network effect in incumbents network can be.

Refering to the post-entry evolution of market structure in Poland, shown in Figure 1, we can conclude that despite Play initially pricing very low, the scale of entry has in fact been smaller than our simple model predicts. This is however due to (i) simplifying assumptions of our simulation framework, which for instance does account for strict contractual switching costs and (ii) simple demand patterns which do not allow for possible correlation between switching costs and network effects. Despite those limitation we believe that our results retain validity and provide valuable insight into the dynamics of post-entry market structure.

6 LITERATURE

Bijwaard, G. E., M. C. Janssen, et al. (2008). "Early mover advantages: An empirical analysis of European mobile phone markets." Telecommunications Policy **32**(3): 246-261.

Calzada, J. and T. M. Valletti (2008). "Network competition and entry deterrence*." The Economic Journal **118**(531): 1223-1244.

Corrocher, N. and L. Zirulia (2009). "< i> Me and you and everyone we know</i>: An empirical analysis of local network effects in mobile communications." Telecommunications Policy **33**(1): 68-79.

Economides, N. (1996). "The Economics of Networks." International Journal of Industrial Organization **14**(6): 673-699.

Farrell, J. and P. Klemperer (2007). "Chapter 31 Coordination and Lock-In: Competition with Switching Costs and Network Effects." Handbook of Industrial Organization **3**: 1967-2072.

Greene, W. H. (2011). Econometric Analysis. Upper Saddle River, NJ, Prentice Hall.

Haucap, J. and U. Heimeshoff (2011). "Consumer behavior towards on-net/off-net price differentiation." Telecommunications Policy **35**(4): 325-332.

Kim, H.-S. and N. Kwon (2003). "The advantage of network size in acquiring new subscribers: a conditional logit analysis of the Korean mobile telephony market." Information Economics and Policy **15**(1): 17-33.

Klemperer, P. (1987). "Entry Deterrence in Markets with Consumer Switching Costs." The Economic Journal: 99.

Maicas, J. P., Y. Polo, et al. (2009). "The role of (personal) network effects and switching costs in determining mobile users' choice." Journal of Information Technology **24**(2): 160-171.

Sobolewski, M. and M. Czajkowski (2012). "Network effects and preference heterogeneity in the case of mobile telecommunications markets." Telecommunications Policy **36**(3): 197-211.

Sobolewski, M. and M. Czajkowski (2013). "Switching Costs and Network Effects: How Much Do they Really Matter in Mobile Telecommunications?" WNE Working Papers **29/2013 (114)**.

Train, K. E. (2009). Discrete Choice Methods with Simulation. New York, Cambridge University Press.