On Competition for Market Share in a Dynamic ISP Market with Customer Loyalty: A Game-Theoretic Analysis

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Abstract. Customer loyalty as part of user behaviour has significant impact on the Internet Service Providers' (ISPs) price setting strategies as shown recently in [1,2,3,4]. However, the issue of a dynamic ISP market, where new ISPs enter the market and try to increase their market shares by offering favourable access prices for incumbent ISPs' loyal customers, has not been addressed yet. Furthermore, the cost of entrance is not yet properly dealt with in the previous studies. In this paper, we use the tools from game theory to understand the competition for market share in a dynamic ISP market with customer loyalty. We model the situation by a Stackelberg leader-follower game, and use the model to compute the Nash/Stackelberg equilibria of the game with customer loyalty and different cost models. For simple cost models, we give explicit formulas for the equilibria of the games. For more complex cost models, we use approximation and simulations to illustrate the dynamics of market shares in these situations.

1 Introduction

The economic interactions among service providers of different levels and end-users have been in the focus of interest for several years. These interactions will continue to get special attention, since initiatives like the NSF FIND [5] and Euro-NF [6] promote economic incentives as a first-order concern in future network design. In addition, user behaviour also has a significant impact on the design of next-generation network architectures as well as creating profitable services running them. Also, decision-makers trying to work out a plausible solution for the recently surfaced net neutrality debate would greatly benefit from an in-depth understanding of economic processes inside the user-ISP hierarchy. There is broad literature in the area of modelling interactions between ISPs with game-theoretical means [7,8,9]. While these papers introduce and analyse complex models for the interaction of ISPs at different levels of hierarchy, they mostly assume a very simple user behaviour model when investigating the market for local ISPs: end-users choose the cheapest provider assuming that the

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quality of the certain services is the same. This assumption could be plausible in certain scenarios, but it could be misleading if there are loyal customer segments present in the market. A vivid example of customer loyalty in practice is the loyalty contract between a service provider and a customer. The customers are charged with different price if they sign a contract and this difference depends on the length of the contract! In [10] authors use a game-theoretic framework to prove that if loyalty is an additional product of market share and penetration, customer retention strategies seem to be consequently more efficient for market leaders. Another study [11] analyses a duopolistic price setting game in which firms have loyal consumer segments, but cannot distinguish them from price sensitive consumers. [12] presents a duopolistic price setting game, where loyal and also disloyal customers are on the market. The companies set prices based on the number of their loyal customers, therefore the Nash equilibrium of the game changes resulting higher utilities.

A number of empirical studies deal with user loyalty on the ISP markets, we shortly review some of them as a global picture. The 2005 Walker Loyalty Report for Information Technology shows that 38 percent of the enterprise customers in the USA have been truly loyal to their Internet Service Providers [13], while Choice survey states that 90 percent of the household respondents had not changed their ISP in the previous 12 months including contract-users as well [14]. [1] states that customer loyalty towards ISPs does exist in Taiwan too. National communication authorities of European Union's countries carry out market research dealing with customer loyalty toward local ISPs. UK's Office of Communications' 2008 Communications Market Report states that 27 percent of broadband users have already switched at least once their provider. Furthermore, the dynamics of the ISP market is illustrated with real market shares, e.g. BSkyB entered the UK ISP market in 2005, two years later it had almost 10 percent of the connections [15]. The consumer ICT survey of Commission for Communications Regulation of Ireland reveals that 84 percent have not change their ISP in the last 12 months [16]. 81 percent of broadband customers said that they do not intend to change Internet operator in the next 12 months finds out Anacom of Portugal [17]. According to a recent report [18], in Finland 16 percent of the subscribers have switched their ISP in 2007 mainly because of a better offer from a competitor. The Malta Communications Authority' survey states that 84 percent of respondents have not switch their Internet Service Provider in the last two years [19]. We carried out a survey on the customer loyalty issue for the Hungarian ISP market, 60 percent of the questioned people do not change their ISP in the last five years. The analysis of our own survey shows that subscriber loyalty depends on the price difference of the current and the possible future service providers, users would become disloyal if the price difference is large enough.

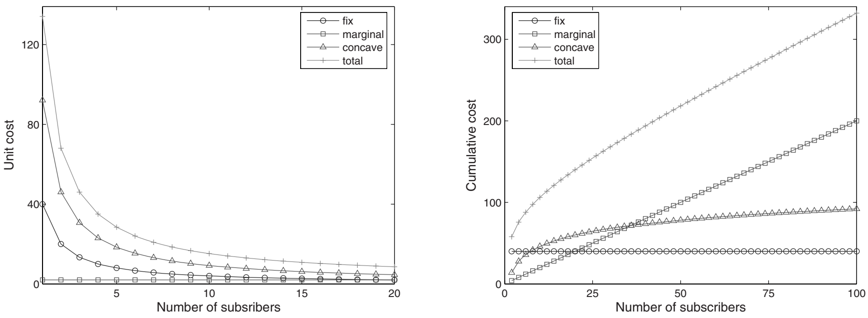
These works and recent works [2,3,4] initiate the discussion on customer loyalty and its impact on pricing strategies of ISPs. However, a number of issues are still to be solved. First, these works use simple or any cost models, usually zero cost is supposed for every Internet subscription, which does not describe the costs which ISPs have to face (e.g. fixed and variable costs). Second, these works deal with static market scenarios when fixed number of service providers exist on the market and they compete for the customers, to our best knowledge the dynamics of the ISP market has not been examined yet. From the arguments above, in this paper we address these issues and try to give answers to these open questions. The ISP market changes dynamic if a new service provider enters to it. The new as well as the incumbent ISPs have to select their price setting strategies based on the costs of providing Internet access, on the cost of entering and on the current market situation. To model the dynamics of the ISP pricing competition, we use Stackelberg leader-follower game. Based on our game-theoretic model we quantify the effects of dynamics and costs on ISPs' price setting strategies and market shares.

The paper is structured as follows. First, in Section 2, we summarize the basics of Internet Service Providers' costs and propose an ISP cost model. Section 3 provide a game-theoretic model for pricing Internet access on a dynamic ISP market in particular when a new ISP wants to start providing access. We use Stackelberg leader-follower game to calculate the equilibrium market shares and profits of the ISPs. We present equilibrium strategies of a dynamic market with loyal customers using different cost models in Section 4, a simple and a full cost model will be examined. In addition, we quantitatively illustrate the changes based on simulation results. Finally, Section 5 concludes the paper.

2 Modelling Cost of Providing Internet Access

Providing local Internet access is a typical example for the so called economics of scale principle, which means cost advantages that a firm obtains due to expansion, because ISPs have to deploy a fixed cost large-scale transporting network. In this section we review the basics of ISPs' costs and present our ISP cost model. The cost of providing Internet access has significant effect on ISPs' pricing strategies because the prices have to be selected to cover the expenses.

The operators' costs can be partitioned based on several aspects [20]: timing (historical or current cost), association (direct, indirect, shared) or its behaviour as production increases. For our goal this last one is the most relevant because on a dynamic ISP market the amount of costs belonging to different number of subscribers determines the pricing decisions of ISPs. On the one hand, costs can be *fixed* (or volume insensitive), if they are constant for a given range of subscribers. The value of fixed costs may vary in long term, e.g. the provider decides to buy a new facility. On the other hand, *variable costs* depend on the number of users, in case of networking services the functions of variable costs are usually decreasing. In addition, the same cost can belong to different categories based on the transporting media. For example, transmission and infrastructure cost is variable in case of wireline media based on FCC's HCMP (Hybrid Cost Proxy Model) tool [21], but it can be considered as fixed cost in case of a licensed spectrum wireless service. A cost model of an ISP can include the followings: Capital Expenditures (CAPEX) e.g. deployment costs, access installation,



(a) Unit costs (b) Cumulative costs

Fig. 1. The different types of cost of Internet Service Providers

Operational Expenditures (OPEX) including maintenance, network management, billing, Internet transit cost, commercial, costumer care costs, etc.

Numerous publications examine the costs of service providers and present the relation of the number of the subscribers and the total cost, including [22,23,24,25]. [22] gives a comprehensive description of the costs of Internet Service Providers and presents ISP specific market and provider segmentation techniques and accounting methods. In addition, a new ISP cost model is proposed and applied to different ISP scenarios. [23] describes relevant Operational Expenditures elements, these elements are modelled as functions of parameters, e.g. number of customers or network devices. The presented grouped list of OPEX elements can be used to perform business case analysis. [24] investigates the costs of Internet access using cable modem and ISDN. Furthermore, it proposes a ISP cost model and based on detailed simulation results the effect of the number of subscribers on total costs is quantified for both technologies. [25] presents economic considerations of FTTX deployment, similar decreasing unit cost figures are shown in the case studies.

A common finding of these papers is the shape of the total cost function of a service provider, which is similar to a logarithmic function. However, none of these works suggest a cumulative cost function with few parameters, they either present only simulation results, or propose formulas for single type of costs. Therefore, we model the costs of the ISPs with the $F_c(n) = nc + c_l(n) + C_{fix}$ cost function where n is the number of subscribers and the three cost types are as follows:

- c marginal cost - constant cost of a subscriber
- $c_l(n)$ concave cost - a logarithmic function of the number of users
- C_{fix} fix cost - independent from the number of subscribers

In practice, the magnitude of these cost types are usually not equivalent, based on the specific scenarios, one type could be considered relatively negligible to other types. In particular, in this paper we deal with two models of ISP costs:

first, we examine the dynamic ISP market with only marginal costs as a simple model to gain insights, then the full cost model will be assumed. We illustrate the three type of costs on Figure 1. Figure 1(a) plots the unit costs of a subscriber as the number of the users increases, while Figure 1(b) shows the cumulative costs of a provider.

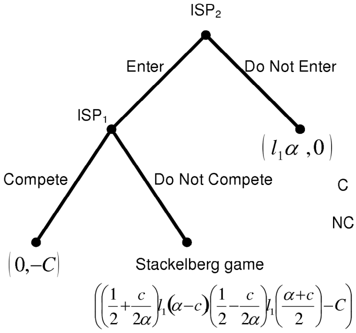
3 Dynamic ISP Market with Loyal Customers as a Stackelberg Game

The market of Internet Service Providers is open, namely a new firm can enter or left the market easily. ISPs have loyal customers who usually do not change their providers. It is an interesting situation when a new ISP enters the market, because the entrant ISP wants to get customers from the incumbent companies. In this paper we examine those ISP market scenarios where the number of the service providers increases.

We model the entry situation in the following way: there are N Internet Service Providers on the market and a new ISP wants to enter to provide Internet access for customers. The cost of entry is C which represents the capital expenditures (CAPEX), e.g. the price of network equipments, the cost of facilities, the cost of access devices. We suppose, that these costs have to be paid once, when the firm enters the market.

The local Internet access market is modelled as follows. The demand for Internet access is constant until an α reservation price, everyone can afford to have Internet access if there exists an ISP whose price is lower than α. Every ISP has customers who are loyal to their provider, formally ISP_i has l_i loyal subscribers. Everyone who has an Internet subscription belongs to an ISP, there do not exist independent users on the market. Different ISP customer loyalty models have been proposed earlier. [3] presents double-price reservation price loyalty models, both deterministic and stochastic one. Price difference dependent loyalty models are proposed by [4] including step based, threshold based and uniformly distributed models. We will use the last model in this paper, i.e. loyal customers are price difference dependent namely if there exist a cheaper provider a fraction of the customers leave their current ISP. We model the loyalty of the ISP_i's subscribers with a linear function, a provider looses $L_i = \frac{p_i - p_j}{\alpha} l_i$ customers if ISP_j has a lower price ($p_j < p_i$). We suppose that every ISP plays rationally, i.e. selects its profit maximising strategy.

We model the entry situation with a sequential game. First, the entrant ISP selects an action, she can enter to the market or not. If the entrant ISP decides to enter, the incumbent providers have two possibilities: set a low enough price to keep all of her customers or set a profit maximizing price. On Fig. 2 we illustrate the two-player version of the game with the utilities of the cases both in extensive and strategic form. The calculations of the profits will be presented later in this paper. We can see that the threat of ISP_1, set c as price, is non-credible, because if the new ISP enters the market the incumbent can have higher payoff if she do not play this option. Accordingly, if it is worth for ISP_2 to enter, the ISPs will



	NE	E
C	$(l_1\alpha, 0)$	$(0, -C)$
NC	$(l_1\alpha, 0)$	$\left(\left(\frac{1}{2}+\frac{c}{2\alpha}\right)l_1(\alpha-c)\left(\frac{1}{2}-\frac{c}{2\alpha}\right)l_1\left(\frac{\alpha+c}{2}\right)-C\right)$

Fig. 2. Extensive and strategic form of entering game

play a Stackelberg leader-follower price setting game where ISP$_1$ is the leader of the game and the entrant ISP$_2$ is the follower. ISP$_1$ sets her price first when the entry of ISP$_2$ turns out, after that ISP$_2$ selects her own price. ISP$_2$ decides about the entry based on the number of users who she will have after the entry, if ISP$_2$ can earn at least C she will enter the market.

4 Game-Theoretic Analysis of Dynamic ISP Market with Customer Loyalty

In this section we apply the proposed cost, loyalty and dynamic ISP market models in a game-theoretical analysis. We examine the dynamic ISP market, where loyal customers exist, using different cost models. We start with a simple cost model where only constant marginal cost exists to gain insights of the problem then we extend the simple model to a full ISP cost model.

4.1 Dynamic ISP Market with Linear Cost

In this section we use a simple cost function to model the dynamic ISP market, where only marginal cost exists, namely the cost of providing Internet access for a single user is c. We examine different market scenarios through this section, we first examine the case when an ISP enters a monopolistic market. After that we deal with a market where N ISPs exist and a new ISP enters, finally we discuss cases where more than one ISPs enter to a market.

A simple model: one incumbent - one entrant ISP. First, only ISP$_1$ exists on the market who has l_1 loyal customers which is the whole demand. The cost of providing Internet access for a single user is c, while α denotes the largest price, at customers still buy Internet access. ISP$_2$ has to set always a smaller price than ISP$_1$ otherwise she would not have any customers. The payoff function of the ISPs is $\Pi_i = l_i^*(p_i - c)$, where l_i^* denotes the number of the ISP's customers at

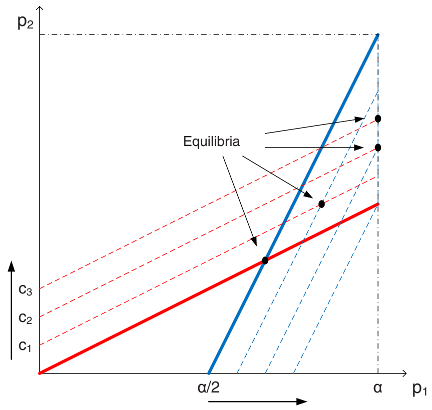


Fig. 3. Best response function of one incumbent and one entrant ISP game at different costs

the equilibrium. ISP_1 will have $l_1^* = \left(1 - \frac{p_1 - p_2}{\alpha}\right) l_1$ users after ISP_2 entered the market, while ISP_2 will have $l_2^* = \frac{p_1 - p_2}{\alpha} l_1$ customers. Accordingly, the payoff of the service providers can be expressed as $\Pi_1 = \left(1 - \frac{p_1 - p_2}{\alpha}\right) l_1 \left(p_1 - c\right)$ and $\Pi_2 = \frac{p_1 - p_2}{\alpha} l_1 \left(p_2 - c\right)$.

Based on the payoff functions the best response function of the ISPs can be calculated, the proof yields $BR_1 = \frac{c + \alpha + p_2}{2}$ and $BR_2 = \frac{c + p_1}{2}$ as best response functions. We show the best response functions and illustrate the effect of the cost (c) on Figure 3.

The ISPs play leader-follower game, where ISP_1 is the leader, she selects her price based on the best response function of the entrant ISP, after that ISP_2 - the follower - sets her price. $p_{max} = \alpha + c$ is the optimal price which maximize $\max_{p_1} \Pi_1(p_1, p_2) = \left(1 - \frac{p_1 - BR_2(p_1)}{\alpha}\right) l_1(p_1 - c)$, the payoff of ISP_1. ISP_1 can not set $\alpha + c$ as price because in this case none of the subscribers would buy Internet access from her. Thus, ISP_1 will set the highest possible price α in order to have maximal payoff. The follower ISP_2 calculates the best response price for this, which is $p_2 = \frac{\alpha}{2} + \frac{c}{2}$. Using these Stackelberg equilibrium prices we calculate the market shares and the payoffs:

$$
\begin{array}{ll}
p_1^S = \alpha & p_2^S = \frac{\alpha}{2} + \frac{c}{2} \\
l_1^S = \left(\frac{1}{2} + \frac{c}{2\alpha}\right) l_1 & l_2^S = \left(\frac{1}{2} - \frac{c}{2\alpha}\right) l_1 \\
\Pi_1 = \left(\frac{1}{2} + \frac{c}{2\alpha}\right) l_1(\alpha - c) & \Pi_2 = \left(\frac{1}{2} - \frac{c}{2\alpha}\right) l_1 \left(\frac{\alpha}{2} + \frac{c}{2}\right)
\end{array}
$$

The results illustrate the effect of a newly entering Internet Service Provider. We note that it can be showed that the property of the Stackelberg games holds also in this case, namely the payoff of the leader at the leader-follower game is larger or equals to the Nash equilibrium payoff.

Generalized model: N incumbents - one entrant ISP. In the previous section we have seen the payoffs and the market shares if a new ISP enters to a monopolistic market. Usually there exist more than one ISP on the market when a new ISP wants to enter. In the followings we suppose that the incumbent service providers do not increase the number of their subscribers, they do not grab users from each other. Only the entrant ISP will have new customers from the incumbent companies because her price has to be the smallest otherwise she would not have any subscribers because switching subscribers select the cheapest offer. Accordingly, in the following game the entrant ISP will set the smallest price.

There exist $i = 1, \ldots, N$ ISPs on the market who are selling Internet access to their customers, ISP_i has l_i loyal customers. The new ISP_j enters the market, she does not have any subscribers at the beginning. The service providers play a leader-follower game where the incumbent companies are the leaders, they set their prices first, while the entrant ISP is the follower of the game. The payoff functions of the service providers are as follows:

$$\Pi_i = \left(1 - \frac{p_i - p_j}{\alpha}\right) l_i \left(p_i - c\right) \quad i = 1, \ldots, N \tag{1}$$

$$\Pi_j = \sum_i \frac{p_i - p_j}{\alpha} l_i \left(p_j - c\right) \tag{2}$$

The best response function of the entrant ISP maximizes her payoff, it can be expressed as $BR_j(p_1, \ldots, p_n) = \frac{c}{2} + \frac{\sum_i l_i p_i}{2 \sum_i l_i}$. The incumbent ISPs maximize their profits based on the entering ISP's best response function:

$$\begin{aligned}
\max_{p_i} \Pi_i(p_i, p_j) &= \max_{p_i} \left(1 - \frac{p_i - p_j}{\alpha}\right) l_i \left(p_i - c\right) = \\
&= \max_{p_i} \left(1 - \frac{p_i - BR_j(p_1, \ldots, p_n)}{\alpha}\right) l_i \left(p_i - c\right) = \\
&= \max_{p_i} \left(1 - \frac{p_i - \left[\frac{c}{2} + \frac{\sum_i l_i p_i}{2 \sum_i l_i}\right]}{\alpha}\right) l_i \left(p_i - c\right)
\end{aligned}$$

The calculations yield the following implicit expressions for the Stackelberg equilibrium prices:

$$p_k^* = \frac{(2\alpha + c) \sum_i l_i + \sum_{i \neq k} l_i p_i}{2 \sum_i l_i + l_k} \frac{1}{2} + \frac{c}{2} \quad k = 1, \ldots, N \tag{3}$$

$$p_j^* = \frac{c}{2} + \frac{\sum_i l_i p_i}{2 \sum_i l_i} \tag{4}$$

The equilibrium prices produce a system of linear equations, where the variables are the prices of the ISPs. The equilibrium prices of the Stackelberg ISP price setting game solve the following system of linear equations:

$$\begin{pmatrix} 1 & -\frac{1}{2}\frac{\sum_{i\neq 2} l_i}{2\sum l_i - l_2} & \dots & -\frac{1}{2}\frac{\sum_{i\neq n} l_i}{2\sum l_i - l_N} & 0 \\ \vdots & \ddots & & \vdots & \vdots \\ -\frac{1}{2}\frac{\sum_{i\neq 1} l_i}{2\sum l_i - l_1} & \frac{1}{2}\frac{-\sum_{i\neq 2} l_i}{2\sum l_i - l_2} & \dots & 1 & 0 \\ \frac{l_1}{2\sum l_i} & \frac{l_2}{2\sum l_i} & \dots & \frac{l_N}{2\sum l_i} & 1 \end{pmatrix} \begin{pmatrix} p_1^* \\ \vdots \\ p_N^* \\ p_j^* \end{pmatrix} = \begin{pmatrix} \frac{1}{2}\frac{(2\alpha+c)\sum l_i}{2\sum l_i - l_1} + \frac{c}{2} \\ \vdots \\ \frac{1}{2}\frac{(2\alpha+c)\sum l_i}{2\sum l_i - l_N} + \frac{c}{2} \\ \frac{c}{2} \end{pmatrix}$$

The equilibrium prices determine the new market shares of the Internet Service Providers:

$$l_i^* = \left(1 - \frac{p_i^* - p_{n+1}^*}{\alpha}\right) l_i \quad i = 1, \dots, N \tag{5}$$

$$l_j^* = \sum_i \frac{p_i^* - p_{n+1}^*}{\alpha} l_i \tag{6}$$

The equilibrium profits of the ISPs are the product of the market shares and the equilibrium prices, namely $\Pi_k^* = l_k^*(p_k^* - c), k = 1, \dots, N, j$. In Section 4.3 we present simulation results of different market scenarios.

The previously introduced price setting strategies can also be used if more than one ISPs enter the market. In case of providing Internet access the new firms do not have to win a concession tender to start their businesses. Accordingly, we model the situation when more than one ISPs enter the market iteratively. We suppose that the entering firms do not enter the market on a flag day, but they can be order in time. Using this assumption we use our one entrant ISP model iteratively: a new company enters the market, we calculate the new market shares then the next ISP enters the market, etc.

4.2 Dynamic ISP Market with Full Cost

We have seen the equilibrium strategies of ISPs if they have simple costs. In this section we generalize the cost model, thus we examine the dynamic ISP market, where the ISPs have costs based on the full model presented in Section 2. The incumbent ISPs ($i = 1, \dots, N$) has l_i loyal users, the entrant ISP$_j$ does not have any users at start, α is the maximal price at Internet access can be sold. The payoff function of the ISPs are as follows:

$$\Pi_i = \left(1 - \frac{p_i - p_j}{\alpha}\right) l_i \left(p_i - c\right) - C_{fix} - \ln\left[\left(1 - \frac{p_i - p_j}{\alpha}\right) l_i\right], i = 1, \dots, N \tag{7}$$

$$\Pi_j = \sum_i \frac{p_i - p_j}{\alpha} l_i \left(p_j - c\right) - C_{fix} - \ln\left(\frac{p_i - p_j}{\alpha} l_i\right) \tag{8}$$

The incumbent ISPs are the leaders of the game, while the entrant company is the follower. It is interesting, that even on a monopolistic market, the equilibrium prices can not be formulated in closed forms. The best response of the entrant still can be expressed, it is a quadratic equation. The incumbent ISP's best response function is a quartic equation which does not have closed form solution. If the number of incumbents increases the formula gets complicated, the derivative of the entrant ISP's profit is

$$\Pi_j' = \sum_i \frac{\alpha + l_i(c + p_i - 2p_j)(p_i - p_j)}{\alpha(p_i - p_j)}$$

which contains the prices of all incumbent ISPs. Accordingly, the best response of an incumbent ISP is a non-linear function of the best response of all the other ISPs as well because they are included in the entrant's best response function.

Accordingly, how can we model the dynamic ISP market? The first solution is that we numerically express approximating implicit equations for the equilibrium prices. In this case, the incumbent ISPs have quartic equations while the entrant ISP has quadratic one. Then systems of equations have to be made with the combination of the implicit forms, the number of the systems are $2 \cdot 4^N$ which is exponential in the number of incumbents. These are systems of non-linear equations therefore can be computed with approximation methods. At the second solution we define an order of the incumbent IPSs as a leader-follower chain. First, the entrant ISP is expressed because she is the only follower in the game. After that the lowest ordered incumbent is the follower and will be expressed, etc. Using the derived formulas the equilibrium prices can be calculated numerically. Finally, a simpler cost model can be used to model the dynamics of the ISP market as we have done in Section 4.1.

4.3 Simulation Results

We use Matlab to calculate market shares, prices and profits of dynamic ISP markets. For the simple cost model we solve the system of linear equation for the equilibrium prices. First, we present results on the change of market shares. Let us suppose that there are three incumbent ISPs on the market with different

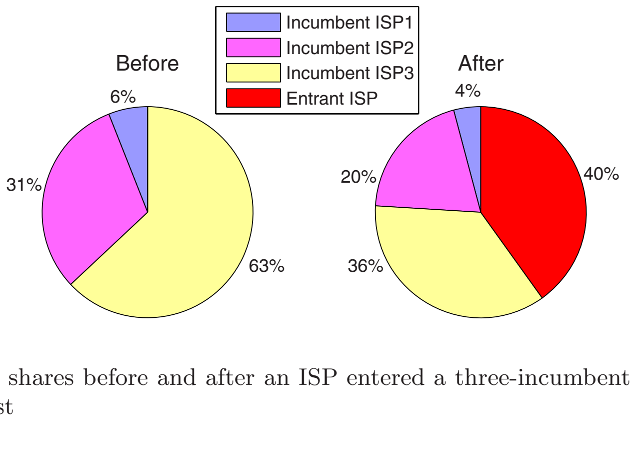


Fig. 4. Market shares before and after an ISP entered a three-incumbent ISP market with simple cost

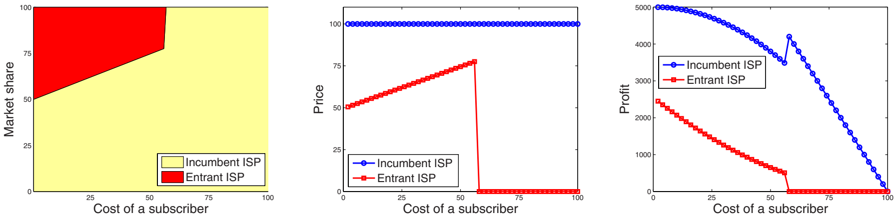


Fig. 5. The impact of unit cost on market shares, prices and profits if an ISP enters a monopolistic market with simple cost

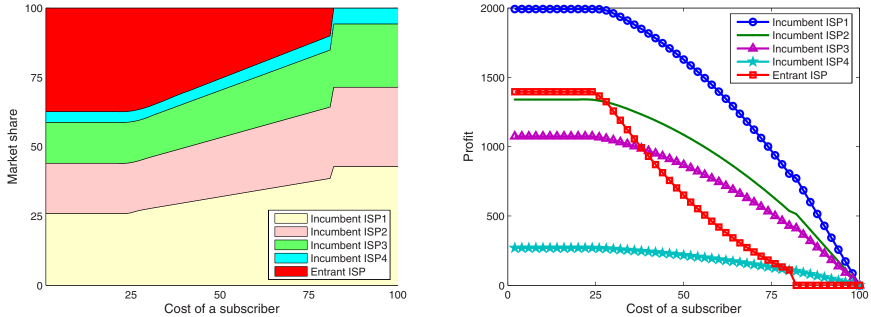
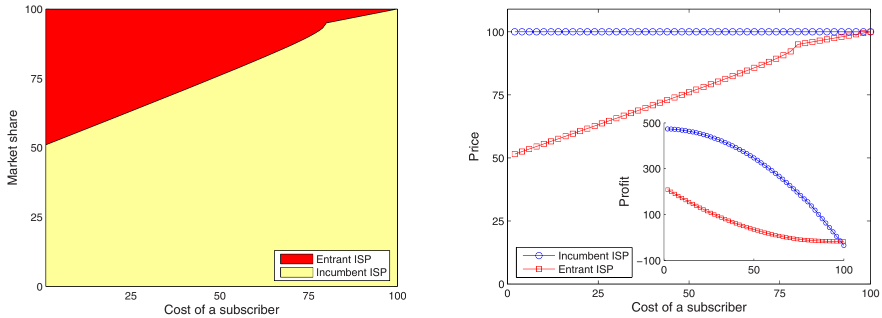


Fig. 6. The impact of unit cost on market shares, prices and profits if an ISP enters a competitive market (four incumbents) with simple cost



(a) Market shares (b) Prices and profits

Fig. 7. Dynamic ISP market with one incumbent and one entrant ISP with full cost

market shares (Fig. 4) and one new ISP enters. In this scenario the entrant ISP can grab a lot of subscribers thus she will be the largest ISP on the market. It can be seen that because the ISPs have the same linear loyalty function, the incumbents loose users based on the ration of their market shares.

We illustrate the effect of the costs on dynamic, simple cost ISP markets. We model a monopolistic market on Fig. 5 where the market shares (Fig. 5(a)), the prices (Fig. 5(b)) and the profits (Fig. 5(c)) are presented as a function of the marginal cost. The cause of the brakes is the cost of the entry (C), if the entrant ISP can not have a profit that covers the entry cost, she will not enter the market. A more competitive ISP market is shown on Fig. 6 where four incumbents exist on the market. We can see similar trends in the market shares and profits as we have seen on the monopolistic market.

We use the ordered incumbents method to calculate the effect of dynamics in case of a full cost, monopolistic ISP market. We have calculated the profit maximising prices with Matlab, the effects of increasing unit cost on market shares, profits and prices are presented on Fig. 7. As we can see the market shares (Fig. 7(a)) and the prices (Fig. 7(b)) are almost linear functions of the cost of subscribers, only around 80 are non-linear parts because of the logarithmic function. The entrant ISP has always smaller payoffs even if the market shares are almost the same, because her prices are always lower than the incumbent's in order to grab customers.

5 Conclusion

In this paper, we have demonstrated how ISPs price Internet access in a dynamic ISP market with customer loyalty, taking in account the impact of dynamics on prices, profits and market shares. We have provided an overview about customer loyalty on global ISP markets. The analysis of our own survey as well as the results from other empirical researches showed that customer loyalty in ISP markets exists. In addition, we have examined the different costs of Internet Service Providers and we have shown which type of expenses are fixed and variables costs. Local ISP markets are dynamic, the number of ISPs and their market shares change continually. We have created a game theoretic model which handles the situation when a new company wants to enter the market. Using Stackelberg's leader-follower game we have shown how much the market shares and the profits of the ISPs have changed on the dynamic market. Furthermore the effect of different costs have been illustrated, both analytically and quantitatively.

As a future research, we plan to investigate furthermore the dynamic ISP market and the effects of costs, where the service providers can have sophisticated price setting strategies (e.g. when a new ISP enters the market, incumbent ISPs select their strategies taking into account the profits of forthcoming months).

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