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Consumer Lock-in Caused by Switching Costs and Network Effects

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Anyának, Apának és Zsófinak

Abstract

Historically small events have an immense inpact on adoption processes. As a result of this an entire industry may end up being locked in to one particular good, service or technology. Lock-in may occur, because of switching costs, network effects or buyers' miscoordination. By modeling consumers' choice in the presence of switching costs and network effects I found, that welfare is greater under large scale entry equilibrium, than under no entry equilibrium and also, that high switching costs can deter even efficient entry thus lock-in consumers to an inefficient firm's good, service or technology. In the switching cost literature the ambiguity of the welfare effects of switching costs allows me to say, that competition law and competition policy makers should evaluate cases in which firms choose to have swtiching costs under rule of reason rather, than per se (il)legality.

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Keywords: Lock-in, Path dependence, Switching costs, Network effects, Coordination

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Contents

1 Introduction

History matters. The reason why this feature plays an important role from the view point of the dynamics of consumers' choice has attempted to being examined in the present paper. In particular, the attention is paid to the phenomenon of consumer lock-in. Generally, the notion of lock-in can be considered as a constraint in the standard consumer utility maximization problem as exogenously given, at least in the short run. From a welfare perspective lock-in can create welfare loss by driving the market into inefficient allocation (i.e. to a state where the allocation of resources is not efficient). Being locked in to a particular technology or standard can deter even an efficient firm[1] from entering the market in question. Hence lock-in may ensure market power for the firm who possesses the locked in consumers. As such, market power is defined as the ability of a firm to profitably raise price above the marginal cost of production. A firm with market power while maximizing her profits may harm consumers' welfare or consumer surplus by setting a price higher than the allocatively efficient level.

In practice among the most relevant indicators of lock-in there are: large market share and also the stability of this market share across time. It is relatively simple to find great empirical examples for locked in industries. Consider for instance the market of personal computer operating systems and in particular the market share of Microsoft Windows. The combined desktop operating system market share of the different versions of Windows is 89.79% (Netmarketshare, 2016), which is relatively high and also stable in time. Another excellent example is the market of desktop search engines where the aggregated (general search engine plus the vertical search engines) share of Google is 70.16% (Netmarketshare, 2016). In addition to this in the market of mobile/tablet operating systems the market share of Android is 65.58% (Netmarketshare, 2016).

Consumers can be locked into a certain technology, standard, consumption of a good or service because of numerous reasons. The presence of lock-in can be attributed to factors such as switching costs, network effects or miscoordination among buyers. Switching costs be explicit or implicit likely to occur when a consumer switches between suppliers of a given good, service or technology. One can consider the case as an instance for switching costs when a customer of a certain bank terminates her current account and opens another one

[1] For the purpose of this text an efficient firm means a firm who has lower variable cost of producing a good or service compared to her competitors.

at a different bank with positive opening fees. Since switching costs cause disutility for the consumer who bears them the action of switching from one firm's good, service or technology to another can be denied or delayed which therefore can give rise to market power for the firm from whom the consumer is unwilling to switch.

In addition to switching costs other potential causing factors of lock-in are network effects. Network effects be direct or indirect are those effects which result in the following perception: my choice hence my utility depends on the choices of my friends, peers, alliances, acquaintances or relationships. The actions of our friends constituting either strategic substitutes or strategic complements have significant impact on our decisions. Consider the example of mobile phones or fax machines. Being the sole person who owns a mobile phone or a fax machine does not create much value for the person on itself. On the other hand, one is better off, if the number of her friends who possess a mobile phone or a fax machine increases, since the growing number of acquaintances having a phone or a fax makes one able to reach more of her peers, keeping everything else equal.

Coordination failures or miscoordination among buyers can also result in consumer lock-in, for instance by deterring an efficient firm to enter the market forcing consumers to keep purchasing from an (inefficient) incumbent. In numerous coordination games such as the one in which players simultaneously decide on which side of the road should they drive have potentially multiple equilibria. In this particular example driving on the left side of the road can be equally beneficial to the players as driving on the right, although players/drivers have to coordinate on which side to employ. Miscoordination means an outcome in which for some specific reason(s) consumers (or agents in general) are unable to coordinate their behavior. Reasons for coordination failures can be lack of communication or bad expectations about future events.

The goal of this paper is dual. On the one hand I attempt to pay attention to issues, that are closely related to the above raised topics, namely consumer lock-in, switching costs and network effects. On the other hand I strive to give a more formal treatment to consumer choice in a scenario where switching costs and network effects are both present. I shall arrive at two main conclusions while modeling the problem of consumers and firms. The first is, that welfare is greater under large scale entry equilibrium, than under no entry equilibrium. In addition to this my second finding claims, that high switching costs can deter even efficient entry, thus lock in consumers to an inefficient firm's good, service or technology. The structure of the paper is as follows: in section 2 I provide an overview of the characteristics of a market of a good, which exhibits network effects. In section 3 the demand side of a (network) good is being examined, meaning that I focus on the behaviour of consumers when network effects, switching costs and potential coordination failures are present. Section 4 deals with a well-known example of the lock-in literature, namely the QWERTY keyboard case. Section 5 scrutinizes the supply side (i.e. the firms' part) of the market. In particular, I pay attention to the following themes: competition for the market, compatibility and I also briefly discuss about entry barriers. Section 6 summarizes the main findings of the most relevant literature on switching costs. Section 7 represents a dynamic game with price setting firms who produce network goods. In the model previously attached consumers have to bear switching costs, if they want to change their supplier. The main improvement of my model relative to previous ones is, that the switching costs of a consumer is endogenous to the number of her switching friends meaning, that it is less costly for an attached buyer to switch supplier, the higher the number of her switching friends, keeoing everything else equal. Finally, section 8 concludes with competition policy implications.

2 Market characteristics of a network good

2.1 Network effects

When a consumer decides which good to purchase she may take into account numerous factors. Among these factors one is able to find network effects. A good, service or technology exhibits network effects, if the utility derived by the consumption of the good, service or technology is affected by the number of other agents who consume the same or compatible good, service or technology in question. A good, service or technology exhibits *direct network effects*, if adoption/purchasing decision by other consumers is complementary, so that each buyer's adoption *payoff*, and her *incentive* to adopt/buy, increases as more others adopt/purchase (Farrell and Klemperer, 2007)[2]. Fax machines, telephones, email, instant messaging applications, languages or the issue of driving on one side of the road are all examples for goods, services or technologies, that exhaust direct network effects (Belleflamme and Peitz, 2010).

[2]Joseph Farrell and Paul Klemperer provide a well-written chapter in the Handbook of Industrial Organization Volume 3 about the topics that I touch, hence I cite their work here, but not necessarily elsewhere.

Furthermore, network goods may exhibit *indirect network effects*. In general, indirect network effects occur in two-(multi) sided markets in, which a two-(multi) sided platform connects the different sides of the market. Examples for two-(multi) sided markets are credit cards, night clubs, Google Search, eBay, etc. The *hardware-software paradigm* well describes what indirect network effects are. Consider the case when consumers adopt a platform, for instance a computer hardware platform. As buyers adopt the same platform, sellers have higher incentive to offer compatible softwares to the hardware and by doing so they increase the value of the original computer hardware platform, which will eventually start the snowball of adoption rolling down the mountain (i.e. it generates more incentives for buyers to adopt and more incentives for sellers to offer compatible softwares). Indirect network effects typically arise in the case of consumer electronics, for instance personal computers (PCs), CD and DVD players or videogame consoles, etc. An other instance of indirect network effects arise, when a costumer buys a popular car and by doing so, it is easier for her to find an aftermarket service supplier, than for a less rife car. Aftermarket service suppliers by observing higher sales of the given car, might want to offer more service, hence make the car more valueable, and so on.

Let me address further decomposition of network effects. The *total effect* means, that a buyer's purchasing/adoption decision of a given good, service or technology makes other costumers of the same or compatible good, service or technology better off, keeping all else equal. The *marginal effect* can be determined as follows: when a consumer pays for a certain good, service or technology she increases other buyers' incentive to buy/adopt the same or campatible good, service or technology in question, ceteris paribus. When each adoption complements every other, then we are dealing with *classic* or *peer-to-peer* network effects. In the case of an instant messaging application she is ceteris paribus better off, if the number of users increases, although the effect may be localized, meaning, that the increase in her utility may be higher when one of her friends adopts rather, than when a stranger adopts. Network effects are *strong*, if each buyer/adopter prefers to follow the action of other buyers/adopters.

It is important to distinguish between network effects and network *externalities*. In general an externality refers to a phenomenon, which does not possess any market clearing price. An effective externality (positive or negative) creates a market failure, if the extern effects are not reflected in the price(s) of affected good(s). Hence, if the positive/negative network effects are internalized in (some) prices, they do not constitute externalities.

2.2 Early power and path dependence

Early power and path dependence is an important consideration when realizing, that there is inertia in decisions or, that a decision about a technology, standard or product at a given point in time may affect the decision and/or the well-being of future decision makers/consumers (Leibowitz and Margolis, 1995).

The notion of *early power* refers to sequential adoption situations where early adopters of a certain good, service or technology have high influence on later adopters' choice set or payoff, thus giving influential power for these early adopters. If early power or first-mover advantage of early adopters is substantial, then early adopters or buyers can be pivotal in adoption decisions. The “New Hampshire Theorem” states, that the preferences of early adopters get more weight than later adopters' in the collective outcome. *Excess early power* means, that early adopters are followed, but this is ex ante inefficient (Farrell and Klemperer, 2007). According to Farrell and Saloner (1985) given preferences, every player is better off moving earlier. In line with this, there are cases where the sensitivity to initial conditions matters a lot, since "historical small events" can cause *path dependency* by defining/influencing the path of a certain process (Arthur, 1989).

Leibowitz and Margolis (1995) distinguish between three type of path dependency. First-degree path dependence is present when sensitivity to starting point exists but has no implied inefficiency. Second-degree path dependency or hypothetical path dependence means a situation in which ex ante selected technology or in general the ex ante decision is inefficient *ex post*. However, processes, which exhaust second-degree path dependence are not inefficient in the sense, that there was lack of information about future outcomes when the decision has been made. Third-degree path dependence is a case in which ex ante more efficient decisions had *not* been, but certainly could have been made (i.e. some agents were aware of the information about the ex ante more efficient technologies) but instead ex ante inefficient technologies had been adopted. In the latter case feasibility of improvement of the path must be present. Third-degree path dependence is a dynamic market failure that is brought by the persistence of certain initial choices. Hence, excess early power, that is ex ante inefficient adoption exhibits third-degree path dependence.

3 The demand side: consumers

3.1 Switching, switching costs and lock-in

Switching is an action of consumers in a repeated purchase scenario, by which they change supplier of a good, service or technology. Consumers can have numerous reasons to find switching an optimal strategy. For instance, consumers may switch, because they are unsatisfied with the quality provided by their actual supplier. In addition to this buyers might want to switch, if they find the price of the given good, service or technology *excessive*. Moreover, costumers may change supplier due to network effects, meaning, that they would be better off, by buying from a different firm, since for instance the other firm has a larger installed base of costumers, which can result in higher (in)direct network effects, therefore in higher utility

Beside the potential benefits caused by switching in a repeated purchase context, consumers on the other hand have to bear *switching costs*, if they indeed change supplier. Switching costs are those, that arise, because a consumer performs a switch from her actual supplier to a different one. Farrell and Klemperer (2007) define the reason for the presence of switching costs as there is economies of scope among someone's serial purchases from solely one firm. In addition to this switching costs might arise, because of investing in equipment, setting up a new relationship or due to costly search (i.e. because of searching costs). Switching costs might be *learning* costs meaning, that consumers have to learn what are the dissimilarities among the usage of the separate goods, services or technologies in question. There might be switching costs, that are *transactional* switching costs, which means reswitching to the initial supplier is costly. The authors further distinguish between switching costs, that constitute real social costs and *contractual* or pecuniary switching costs. Instances for the latter can be loyalty programs such as the frequent-flyer program. The main idea behind loyalty contracts, that they rebate a fraction of past payments by the use of some type of reward point system. Consumers who are contracted in loyalty schemes are chained to the company in the sense, that if they want to use a different supplier's service they cannot enjoy the benefits of the rebates of past actions.

Switching costs are not only interesting from a theoretical point of view, since they also induce certain kind of implications, which have immense impact on practical considerations. Vast amount of the economics literature concentrates on and strives to unambiguously quantify the effects, that switching costs imply on different phenomenons, such as the level of competition in the affected market(s), entry deterrence, lock-in, equilibrium prices, consumer surplus, firms' profits and total welfare. The main results of these studies in addition to my own are going to be presented later in subsequent sections of this paper. Before doing so, let me continue by more accurately specifying the notion of lock-in.

Lock-in means, that even, if consumers are willing to switch from their current supplier, for some specific reason(s) they are unable to do so, hence they are said to be locked in to their actual supplier's good, service or technology. The closely related concept to lock-in is *excess inertia*, which means the following: users fail to switch from an equilibrium, though everyone would be better off. Lock-in may occur, because of switching costs, network effects and/or buyers' miscoordination. For an instance consider a case in which there is an efficient entrant who does not have an installed base of previously attached costumers. The same firm offers a good, service or technology at a lower price compared to the one, that is charged by an incumbent who does have an installed base of formerly committed consumers. Suppose that, if the attached buyers of the incumbent prefer to purchase from the entrant, meaning, if they are better off by switching their purchase they have to bear switching costs. In this scenario it may happen, that despite the better offer of the entrant new uncommitted buyers prefer to purchase from the incumbent thanks to the positive network effects of the installed base, which is unwilling to switch from the incumbent, because of switching costs. Hence the whole market (i.e. attached and unattached buyers) will end up buying from the incumbent, thus the entire industry is locked into to the good, service or technology of solely one firm substantially due to switching costs and network effects. If committed and unattached buyers could coordinate and/or the option of side-payments were available to them, then all buyers could purchase the good, service or technology from the efficient entrant.

3.2 Coordination and miscoordination among buyers

Coordination among consumers may help to solve the concerns raised by lock-in, namely (efficient) entry deterrence and/or lower consumer welfare. Nevertheless, in plentiful coordination or adoption games where agents decide simultaneously, multiplicity of (even pure strategy Nash) equilibria is often present. In fact, players of a certain game are able to coordinate on the 'bad' (from a social welfare viewpoint) equilibria, that is an equilibrium, which is Pareto dominated by other equilibrium strategy profile(s).

Coordination is a complex phenomenon. Notwithstanding the consideration of socially inefficient equilibrium in coordination games, there is another concern, namely, that often times consumers/players fail to coordinate thier behavior at all. The so-called *miscoordination* is present when buyers fail to coordinate their behavior. Miscoordination might occur as a result of poor expectations on future events, conflict in (individual) interests, and/or the lack of communication. Miscoordination of buyers may deter even an efficient firm to enter the market, thus potentially reducing consumer welfare. More fragmented buyers may suffer from more coordination failures, keeping everything else equal. One of the solutions for coordination failures are credible commitments. Miscoordination would not occur, if buyers could agree to adress their orders jointly. The formation of a central purchasing agency, which pool individual orders of independent buyers can be welfare beneficial. According to Chiara and Motta (2008), who examined the question in a vertical setting miscoordination of buyers is less likely, if competition in the downstream market is sufficiently intense. They claim, that higher downstream concentration solves miscoordination, although it creates market power, ceteris paribus.

As an instance for a coordination failure consider the chicken-and-egg problem in a two-sided market with a good, that exhibits indirect network effects. In particular, suppose a new hardware product, which fails, because users are reluctant to purchase such a hardware with no compatible programs. In addition to this, software creators do not develop many programs, that are compatible with the hardware as long there is no installed base of the new hardware (Belleflamme and Peitz, 2010). This problem of Catch-22 or the chicken-and-egg problem, that is the snowball of adoption does not get rolling (i.e. no adoption is an equilibria even with a valueble network good) might be solved by a 'big push', which is a substantial intervention to the market resulting in a change in payoffs.

3.3 Consensus influence

As argued before it is well established, that in markets of certain kind of goods, services or technologies there are consumption externalities, meaning that the utility of a consumer depends on the number of agents who consume the same or compatible good, service or technology in question. Hence consumers' expectations about the size of the network is particularly important. A higher network size, ceteris paribus will lead to a higher willingness to pay for the good (Katz and Shapiro, 1985). Consumption externalities give rise to demand side economies of scale.

Another related topic to network effects is concerned about how information spreads out or flows in different sorts of networks. In the dynamic process of adoption of a new good, service or (typically) a new technology one important notion is the *band wagon effect*. The so-called bandwagon effect can be summarized as follows: consumers who strongly favor technological change switch early, while those buyers who moderately favor the switch wait to see whether other costumers will switch and after then get on the bandwagon[3], if it indeed gets rolling. In some cases early adoption is beneficial, if the given good, service or technology becomes widespread afterwards. These cases are said to be the first-mover's advantage or the advantage of early power. Early adoption is costly at least in the short run when other consumers have not yet adopted or even in the long run, if they refuse to adopt at all, hence timing of adoption gains a critical interest in this scenario. There is symmetric excess inertia, (that is purely a problem of coordination) when buyers would happily get on the bandwagon once it is rolling, but they have insufficient incentives to set it rolling themselves (Farrel and Saloner, 1985).

The bandwagon effect and its results are in line with the concept of wisdom of the crowd, which can be summarized as the following. A group with great number of individuals tends to perform at least as good and usually better as its members in questions, which involve estimation tasks and/or general knowledge problems. The main reason behind this feature is, that averaging noisy individual estimates will abolish the noise and gives a fairly precise estimation of the parameter value in question. Further fascinating topics, such as information flow via networks, information cascades or social learning are out of the scope of this paper, however more research on these topics would certainly result in deeper understanding of the relationship among consumers' choice and consumer lock-in.

4 QWERTYnomics: the economics of QWERTY

Giant number of keyboards are made with the letters QWERTY in the top left corner. Why? Why QWERTY is the keyboard layout standard and not something else? Is this technology efficient from a typist welfare point of view? Is the industry locked in to this standard? Would switching to another keyboard layout be welfare enhancing?

[3] In my previous reasoning I have been using the snowball analogy, though the underlying concept is the same.

According to David (1985) the main reasons behind the usage of the QWERTY standard are the following: technical interrelatedness, economies of scale, and quasi-irreversibility of investments. Technical interrelatedness refers to the necessity for compatibility between the keyboard layout and a typist's knowledge of a particular positioning of the keys. A purchase by an employer of a QWERTY keyboard results in a positive externality to QWERTY trained typists. This feature of QWERTY exhibits indirect network effects, similar to those in the hardware-software paradigm. Moreover, when a typist chooses to study the usage of QWERTY, the cost of previous users' declines, keeping everything else equal. In David's view these economies of scale represent the most important cause of the standardization of the QWERTY keyboard layout. Quasi-irreversibility of investments in typingskills is the result of switching costs of typewriters, since learning how to type on a keyboard with specific layout is a timely, hence a costly process (David, 1985).

Early agents who chose a slow-to-improve technology, while maximizing their current utility can lock the market into this inferior option, while equal development of the excluded technology in the long run would result in a higher pay off. In the QWERTY case an early-established technology becomes dominant, so that later, even superior alternatives cannot gain footing, thus history indeed matters in such dynamic selection mechanisms. With QWERTY increasing returns arise, because of coordination externalities, which can cause, that the economy gradually locks itself into an outcome not necessarily superior to alternatives, not easily altered and not enterily predictably in advance (Arthur, 1989). The standard QWERTY typewriter keyboard is considered to be inferior to the alternative keyboard layout: the Dvorak Simplified Keyboard or DSK, even when retraining costs are taken into account. The possible reason behind QWERTY's excess inertia is the overwhelming benefit from compatibility (Farrel and Saloner, 1985).

On the other hand Leibowitz and Margolis (1990, 2001) argue, that QWERTY is *not* very inferior to DSK. They also claim, that although switching could be privately inefficient for locked-in typists, new non-trained-on-QWERTY typists may find using DSK beneficial (Farrell and Klemperer, 2007). Second-degree path dependence or hypothetical path dependence is present here for the reason, that when QWERTY became used technically superior alternatives were *not* present on the market, only shortly afterwards.

5 The supply side: firms

5.1 Competition for the market

In numerous markets, where fixed costs of production are tend to be so immense, that solely one firm can efficiently supply the entire market, that is the doctrines of economies of scale (and often scope) and cost subadditivity apply, firms ex ante of the production of the good, service or technology in question are *competing for* rather, than in *the market*. In such circumstances the notion of the winner takes it all is absolutely adequate. Consequently for being the sole supplier in the market (i.e. being a monopolist) firms have a tendency to compete tremendously. In addition to this firms also compete for the market in the case of standard setting of a certain good, product or (typically) a technology.

As an optimal strategy firms can engage in penetration pricing, taking losses early on in exchange for potential monopoly rents subsequently (Arthur, 1989). The *bargain-then-ripoff* dynamic pricing strategy describes a concept in, which there are two main phases. In the first stage firms bargain or invest by setting prices below average total cost of production, hence they make losses. Nevertheless, by setting a low price a firm might build up a costumer base. In order to make positive overall profits and/or cover losses in the second ripoff or harvest period the firm will put an excessive (at least compared to the previous) price. Despite the high price in the presence of switching costs or due to the mere fact, that there is only one available supplier in the market, antecedently committed consumers will still purchase from the firm, which they have previously attached to (Farrel and Klemperer, 2007).

In line with this in a market where more, than one firm can still efficiently supply the whole demand switching costs may create the *fat-cat effect*, which can be described as the following. In a repeated purchase scenario where firms cannot price discriminate and in, which changing supplier is costly for consumers an incumbent firm with already committed buyers may set a high price in order to harvest on her base. By doing so she will reach higher per costumer revenues on her committed buyers, however she might loose potential new, unattached consumers. On the occasion the profit enhancing effect is larger on the margin, then the losses caused by the deterring effect on uncommitted costumers, the fat cat (i.e. the incumbent) would focus more on harvesting on her previously attached consumer base rather, than setting a low price to attract more buyers, hence own a larger base of costumers. Under the price umbrella of the fat cat even an inefficient entrant can profitably enter the market and supply new, unattached consumers.

5.2 Compatibility

On the one hand when incompatible standards are competing *for* the market, that is to say there is a standard war competition takes place in the present, meanwhile when there is compatibility between different competing firms' goods, services or technologies likewise after a standardization process competition *in* the market takes place subsequently among distinct suppliers who use the same standard. Compatibility[4] can be achieved by the joint adoption of a product standard or via the construction of an adapter. The notion of *backward-compatibility* or downward compatibility, means that a good, service or technology, which has been launched at a later point in time is compatible with a previously introduced good, service or technology, but not necessarily the other way around (Shy, 2004). When allowing for interoperability among different firms' goods, services or technologies there are two main effects, which should be taken into account. The first effect is the demand expansion effect, meaning, that by making two substitute goods compatible with each other the costumer base of every participating firm increases per se. Nonetheless, firms should be concerned about the second effect of interoperability, that is the reduction in quality differentation, which might be welcomed by a firm with modest market share, but opposed by a firm with considerable market share.

Cost sharing agreements or side payments can solve the problem of lack of private incentives for complete compatibility. In a case where one firm has private incentive for compatibility an other firm (which does not have such an incentive) may pay for the first firm for preventing her making compatible goods[5] (Katz and Shapiro, 1985). Therefore the permission of side payments, patent and copyright laws have significant effects on compatibility and technology adoption.

Besides the beneficial consequences of compatibility it can lock in an industry into an inferior standard when there is a better alternative. According to Farrel and Saloner (1985)

[4]For instance in the telecommunication sector, compatibility in the form of interconnection is mandatory.

[5]This feature or finding is quite similar to those cases in the pharmaceutical industry which are the so-called pay for delay agreements. In pay for delay agreements an originator of a given drug pays one or more generics in order to delay their entering to the market of the same drug, hence longering the monopoly of the originator or in other words delaying competition.

with complete information and identical firms no, but with incomplete information excess inertia can occur. The authors found that inefficient inertia cannot be entirely solved by communication across firms. In fact, in practice most standardization is volountary, because of the presence of network externalities among producers. When timing of the adoption of a new technology becomes endogenous to the firms, the authors find, that there is a bias towards switching from the old technology to the new standard.

On top of this it is also true, that under some circumstances somewhat surprisingly compatibility can raise prices, since interoperability between goods, services or technologies reduces incentives to cut prices, keeping everything else equal. The reasoning behind this finding is similar to the one, that is used in horizontal merger cases. A merger between firms at the same level of the supply chain who supply products, which are substitutes internalize the pricing externality of one firm on the other. Nonetheless, it is noteworthy, that a merger removes all sorts of competition among the participating firms, while the adoption of a common standard, which makes goods compatible replaces incompatible competition with compatible competition between firms.

5.3 Barriers to entry

Stigler (1968) poses the definition of an entry barrier as a cost advantage that an incumbent firm enjoys compared to entrants. With such an advantage, the incumbent firm can permanently elevate its price above its costs and thereby earn excessive returns. In addition to cost advantages, switching costs can discourage large scale entry, because this would induce the installed base of the incumbent to switch supplier. Furthermore, positive (in)direct network effects may prevent small scale entry as a result of the great positive network effects of the installed base. Henceforth switching costs and network effects might imply barriers to incompatible and/or efficient entry (Farrel and Klemperer, 2007). According to Katz and Shapiro (1985) network effects are similar to fixed cost of production in the sense, that they can create an entry barrier. What is more, that coordination failures or miscoordination among buyers can also constitute as a barrier to entry.

In any case the fact can be admittedly acknowledged, that an installed base of previously attached costumers similarly to market share is a valueable asset for a firm. In general switching costs and/or network effects can lead to an installed base of consumers who is unwilling to switch from their current supplier. As a consequence, the firm with such an installed base of costumers is able to leverage its market power by exploiting her price insensitive consumers via setting an excessive price without inducing (much) switching. However, as I have highlighted before by putting a high price the firm might induce even an inefficient supplier to enter the market in question.

6 Literature Overview

Given that switching costs explain a great proportion why lock-in occurs it is reasonable to look at what are the effects of swicthing costs on the level of competition in markets and on economic welfare. Are prices higher or lower in the presence of switching costs? Are markets more or less competitive under switching costs? Most studies suggest that switching costs lead to higher prices, however in a dynamic competitive environment switching costs have two effects (Cabral, 2016). They increase the market power of a seller with locked in customers. On the other hand switching costs increase competition for new unattached buyers.

According to the Cabral (2016), if markets are very competitive, then switching costs make them even more competitive, whereas, if markets are not very competitive, then switching costs make them even less competitive. By more competitive market the author means, that firms have similar probabilities of attracting customers or a market with a high discount factor, meaning, that the importance of competition for future customers is relatively high compared to the importance of current revenues. If sellers cannot price discriminate between locked in and non-locked in customers, then one would expect that switching costs are anti-competitive. In the early literature of switching costs (Klemperer, 1987) authors emphasized the importance of the bargain-then-ripoff pattern. They usually use two-period models, however with those there is an immense concern, namely, that the beginning/end of the world effect can bias results.

As I have just noted above Cabral (2016) finds an U-shaped function between average prices and switching costs, with average prices on the vertical and switching costs on the horizontal axis. Put it differently at small values of switching costs the increase in switching costs is pro-competitive (i.e. it decreases average prices), while above a certain threshold switching costs are anti-competitive (i.e. they raise average prices). Switching costs make entry more difficult, since facing an incumbent with locked-in customers the potential entrant finds entry less attractive. Padilla (1992) uses a two-period model to find the relationship between the level of competition in markets where consumers have switching costs. In his model one of the results is that, ex ante identical firms have ex post asymmetric market shares in equilibrium. Padilla (1992) assumes that consumers have different information of market supply and also, that consumers leave the market at the end of the first period with positive probability. Importantly the more asymmetric the market is (in terms of market shares) the larger firm has a higher incentive to exploit her old buyers by raising price (the fat cat effect), although by doing so she gives up some of the new costumers. There are asymmetric market shares in equilibria because of the fact, that the probabibility of setting the same price (i.e. the probability of a tie) by the two firms is zero. Switching costs have the effect of making the residual demand which firms face more inelastic, thus increasing firms' market power. One of the main findings of the paper is: an increase in the proportion of the locked in buyers makes first-period competition more fiercer and second-period competition milder, although the effect is not monotonic. The second-period anti-competitive effect only dominates, if the probability of leaving the market is sufficiently high. In general, market expansion generates fiercer competition in the second period, however its effect on first-period competition is ambiguous. An other finding is that, the incumbent by committing to a lower market share ensures a fiercer competition in the event of entry. Padilla (1995) in his dynamic doupoly price setting model seeks to understand the relationship between consumer switching costs and the level of competition that is captured by the actual level of equilibrium price(s).

In Padilla's (1995) model two firms compete in a market of an ex ante homogenous good, which becomes differentiated ex post because of the switching costs. The time horizon of the game is infinite. The model assumes ovrlapping generations of consumers who live for two periods. The solution of the model is a symmetric and stationary Markovian perfect equilibrium. At every period of the game there are two generations of consumers co-existing: the old locked in and the new uncommitted consumers. The author assumes that, if the two firms set identical prices, then the new buyers purchase from the firm which does not have an installed base of consumers. This assumption is contraversial to those which I follow in my setting, since the positive network effects caused by the installed base have crucial importance in unattached buyers' decisions. Padilla (1995) finds that in a market with positive switching costs prices always exceed marginal costs (i.e. competitive prices). Although firms cannot price discriminate between consumers, on average locked in consumers pay higher prices, than uncommitted consumers. His main result is, that in equilibria there are higher prices and larger profits in every single period, because of switching costs. Firms' prices increase as their respective consumer base grows (the fat cat effect). In the light of collusiveness switching costs reduce the incentive to deviate from a collusive settlement, however they also reduce the severity of the punishment, hence the net effect of switching costs on the sustainability of collusion is apriori unclear.

Fabra and García (2012) claim in their model, that in equilibria the larger supplier admits market share via charging higher prices compared to the small firm. They find two kinds of anti-competitive effects of switching costs in the short run. First of all, the higher the switching costs, the slower the declining rate of average prices and also slower the conversion to a market, which is symmetric, ceteris paribus. Secondly, they claim, if the difference among firms' market shares are above a certain treshold, then a rise in switching costs results in greater actual prices. In the long run switching costs have a pro-competitive effect, as long as firms become more identical in terms of market share, since in such a scenario they compete in prices in a tougher manner. The authors conclude by stating, that switching costs are more problematic in markets with lower number of firms, keeping everything else equal.

7 The model

Consider the following scenario. There are two risk neutral firms $f = I, E$ in a duopoly who compete for consumers[6] in a simultaneous price setting game. Firms produce an *ex ante* homogenous good which exhibits direct network effects. The marginal cost of production for firms I and E is given by c_I and $c_E < c_I$, respectively. Firm I is the incumbent who is already present in the market and has an installed base of costumers, namely the N 'old' buyers. On the other hand, firm E is a potential entrant who wishes to enter the market, however she does *not* have any mass of buyers who had have been previously committed to her. The fixed cost of entering the market is given by: $F > 0$. Beside the N attached costumers of the incumbent there are $\tilde{N}$ 'new' consumers[7] in the market who have not been committed themselves yet. Consumers are homogeneous within, however heterogeneous

[6] To denote consumers I interchangeably use words such as buyers, purchasers, costumers or nodes as a common notion in the network science literature.

[7] There are more old, than new buyers and in each set there are at least two costumers: $N > \tilde{N} > 1$.

across groups. Given the dynamic nature of the game the timing is as follows: in the first stage firm E decides whether to enter the market or not. In the second stage active firms set prices non-cooperatively: P_I and P_E, that is if entry has taken place in the previous period firms compete à la Bertrand, if not firm I sets price as a monopolist. Neither of the firms can price discriminate between costumers. In the third stage of the game[8] buyers have to decide between suppliers, if entry has taken place before.[9] For simplicity firms and consumers discount future values with a discount factor equal to one. A consumer demands one unit of the good inelastically up to her willingness to pay. The $\tilde{N}$ new buyers when deciding from whom to purchase they balance mainly two effects. In general, the unattached costumers are concerned about the (expected) size of the network of the particular good, that is the number of purchasers who pay for the same product. Uncommitted buyers also take into account the price of the good in question. However, the N old buyers when maximizing their own utility they mainly focus on three objectives. Previously committed costumers of the incumbent pay attention to the (expected) size of the network, as well as the price of the given good. Furthermore, old buyers, if they decide to switch from the incumbent (i.e. buy from the entrant) they have to bear *switching costs* denoted by $S(\cdot)$. Formerly attached buyers' switching costs are endogenously determined by the number of their switching neighbors. In particular, the larger the number of an old buyer's switching neighbors, the lower her switching costs are. The endogeneity of switching costs is one of the largest improvement of my model relative to former models. Let me assume incompatibility between the two network goods.

Below I strive to solve the game by using backward induction. By doing so particular attention is paid on the two extremes of the set of subgame perfect Nash equilibriums in pure strategies. The two cases in focus are the no entry equilibrium and the large scale entry equilbrium. Before analyzing those let me describe the problem of the $\tilde{N}$ new consumers at the last stage of the game. At the third stage of the game given, that entry has taken place beforehand the decision problem of the consumers has an adoption flavour, that is the buyers face the problem of which good to adopt or which network to coordinate on. In order to find the solution(s) to this adoption/coordination game I shall display the payoffs of the players given the action of other players and the prices determined by the firms. To be more formal

[8] The game is similar in nature to those described in Jackson (2008) chapter 9. especially to the treshold game of complements and to the coordination game.

[9] If the only active firm is the incumbent, that is there was no entry to the market, I assume, that consumers are better off buying from the incumbent than not purchasing the good at all.

let me define the utility of a new buyer, if she chooses to purchase from the incumbent (i.e. from firm I):

$$U_l(I, a_{N_l(g)}) = \sum_{j \in N_l(g)} \beta u(a_j) - P_I$$

whereas the utilitility of a new buyer, if she buys from the entrant (i.e. from firm E):

$$U_l(E, a_{N_l(g)}) = \sum_{j \in N_l(g)} \beta u(a_j) - P_E$$

for $\forall j, l = 1, ..., \tilde{N}; l \neq j$
where $a_j \in \{I, C\}$ is the possible actions of agent (buyer) k. The payoff followed by the action of agent k is given by: $u(a_j) \in \{a, h, r, c\}$, where $a > r \geq 0$ and also $c > h \geq 0$. $\beta > 0$ is the positive network effect parameter. The first term on the RHS in both equations means, that the utility of consumer $l \in \{1, ..., \tilde{N}\}$ is increasing in the action of other $j \neq l$ buyers who eventually belong to the neighborhood $N_l(g)$ of consumers l, where g represents the adjacency matrix, which indicates, that who is adjacent to whom. The following matrix captures the payoffs of different buyers who decide between the incumbent and the entrant.

$l \backslash j$	I	E
I	a,a	h,r
E	r,h	c,c

Since $a > r$ and $c > h$, in the static one shot game there are two Nash equilibriums in pure strategies, namely (I,I) and (E,E)[10]. However, in order to solve the above described game one should pay attention to other key factors as well as prices, swithing costs and network effects (i.e. the effect of the actions of one's neighbors). Hence, let me continue with the following notion: an unattached consumer prefers the entrant to the incumbent (i.e. $E \succ I$), if and only if:

$$U_l(E, a_{N_l(g)}) > U_l(I, a_{N_l(g)})$$

that is the same as

$$\beta(d_l^I r + d_l^E c) - P_E > \beta(d_l^I a + d_l^E h) - P_I \qquad \forall l = 1, ..., \tilde{N}.$$

Where d_l^I means the number of 'friends' of node (buyer) l who buys from the incumbent, and similarly d_l^E refers to the number of friends of l who purchases from the entrant. Notice

[10]Multiplicity of equilibria is a common feature of coordination games such as the battle of the sexes or the stag hunt game.

that d_l^I and d_l^E are disjoint sets, meaning that a friend of consumer l either buys the good from the incumbent or the entrant but not from both at the same time. Also note, that d_l^I and d_l^E add up to the degree (number of friends each buyer has) of node l (i.e. $d_l^I \cap d_l^E = \emptyset$ and $d_l^I + d_l^E = d_l$). Without loss of generality let me assume, that $h = r = 0$. Thereby a new buyer chooses to purchase from the entrant, iff:

$$d_l^E > t_l \equiv \frac{a}{c} d_l^I + \frac{P_E - P_I}{\beta c}$$

where t_l is the *treshold* of buyer l for $\forall l = 1, ..., \tilde{N}$. This means that, if the number of friends of consumer l exceeds her treshold t_l, then she is better off buying from the entrant. As d_l^E, the treshold of a new buyer: t_l, varies in the interval of $[0, d_l]$. The higher a new buyer's treshold is, the less likely it is, that she buys from the entrant, keeping everything else equal. Now let me perform some comparative statics on buyer l's treshold. Ceteris paribus, if the number of l's friends who buys from the incumbent (i.e. d_l^I) increases, so does the threshold since $\frac{a}{c} > 0$, making it less likely, that l will purchase from the entrant. If the price of the entrant (incumbent) escalates, then the treshold of a new buyer increases (decreases) making her less (more) likely to buy from the entrant, keeping everything else unchanged. The effect of growth in parameter a is non-negative on the treshold of an unattached costumer, while an increase in the value of parameter c favors the entrant (i.e. lowers the treshold), if $d_l^I > \frac{P_I - P_E}{\beta a}$. Having considered the problem of the $\tilde{N}$ uncommitted buyers, let me turn the attention to the problem of the installed base of the incumbent, that is the N old buyers. Similarly as above, the utility of an old buyer who chooses to stay and purchase from the incumbent is given by:

$$U_i(I, a_{N_i(g)}) = \sum_{k \in N_i(g)} \alpha u(a_k) - P_I$$

whereas the utility of an attached consumer who decides to switch from the incumbent and buy from the entrant is as follows:

$$U_i(E, a_{N_i(g)}) = \sum_{k \in N_i(g)} \alpha u(a_k) - P_E - S(d_i^E)$$

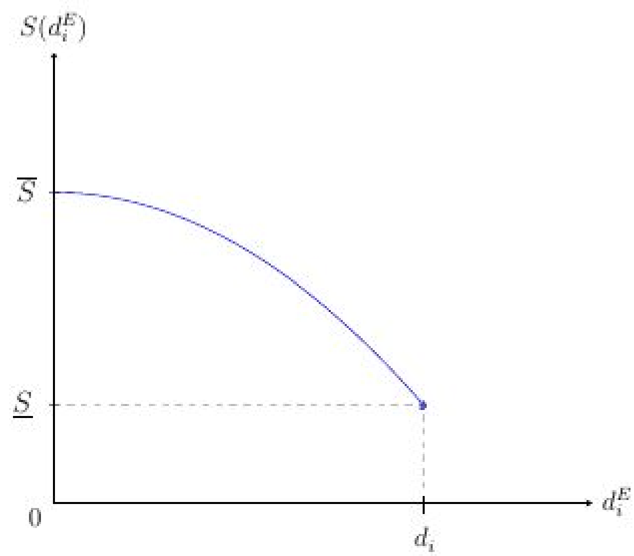
for $\forall k, i = 1, ..., N; k \neq i$

where $a_k \in \{I, C\}$ is the possible actions of consumer j. The utility followed by the action of buyer j is given by: $u(a_k) \in \{a, h, r, c\}$, where $a > r \geq 0$ and $c > h \geq 0$ and also $\alpha > \beta > 0$. The payoff matrix is the same as described before, so let me not repeat it here. The substantial difference between the utility function of an attached consumer who decides to switch and all the other utility functions above, is captured by the term $S(d_i^E)$, that is the switching cost of consumer $i \in \{1, ..., N\}$. The same notation applies here as above, namely, that the degree of an old consumer is the sum of her switching and 'staying' or locked-in neighbors, formally $d_i = d_i^I + d_i^E$. As I have mentioned earlier attached buyers' switching costs are endogenously determined by the number of their switching neighbors (i.e. by d_i^E). Thus I define the switching cost of consumer i who is an attached buyer of the incumbent as the following:

$$S(d_i^E) = \begin{cases} \overline{S} - (d_i^E)^2 & \text{, if } d_i^E \in [0, d_i) \\ \underline{S} & \text{, if } d_i^E = d_i \quad \text{where} \quad \overline{S} > \underline{S} \geq 0 \end{cases}$$

graphically:

Figure 1: Attached consumers' switching costs



The particular shape of the switching cost function exhibits the following: $\frac{\partial S(d_i^E)}{\partial d_i^E} < 0$ and also $\frac{\partial^2 S(d_i^E)}{\partial (d_i^E)^2} < 0$. In words this means, that the higher the number of i's friends who switch to the entrant the lower i's switching costs. In addition to this, as the number of switching friends of an old buyer increases, switching costs decrease in a more rapid manner. $\overline{S}$ is the maximum level of switching costs, which occurs, if nobody from i's neighborhood switches (i.e. when $d_i^E = 0$). $\underline{S}$ can be interpreted as the minimum level of switching costs, which has to be beared for sure by an attached consumer who indeed switches from the incumbent to the entrant. Old buyer i prefers the entrant to the incumbent, meaning, that she is better off by switching supplier, if and only if:

$$U_i(E, a_{N_i(g)}) > U_i(I, a_{N_i(g)})$$

that is the same as

$$\alpha(d_i^I r + d_i^E c) - P_E - S(d_i^E) > \alpha(d_i^I a + d_i^E h) - P_I \qquad \forall i = 1, ..., N.$$

If $h = r = 0$ as before, then we have the following relation:

$$\alpha d_i^E c - P_E - S(d_i^E) > \alpha d_i^I a - P_I$$

In contrast to the previous analysis here two cases have to be distinguished. In the first case $d_i^E = d_i$ whilst in the second case $d_i^E < d_i$. If $d_i^E = d_i$, then $d_i^I = 0$ and $S(d_i^E) = \underline{S}$ by definition. Hence the following remains:

$$\alpha d_i^E c - \underline{S} > P_E - P_I$$

or equivalently

$$d_i = d_i^E > t_1 \equiv \frac{P_E - P_I + \underline{S}}{\alpha c} \qquad \forall i = 1, ..., N$$

where t_1 is the treshold of attached consumers in the first case. The first treshold for old consumers: t_1 is increasing in the price of the entrant (P_E) and also in the minimum level of switching costs ($\underline{S}$), which implies lower willingness to switch supplier, keeping everything else equal. On the other hand, increasing the price of the incumbent favors switching to the entrant, ceteris paribus. As parameter c grows treshold t_1 drops, which is in favor of switching, if $P_E + \underline{S} > P_I$, holding everything else the same.

In the presence of the second case, when $d_i^E < d_i$ we are left with the following quadratic inequality:

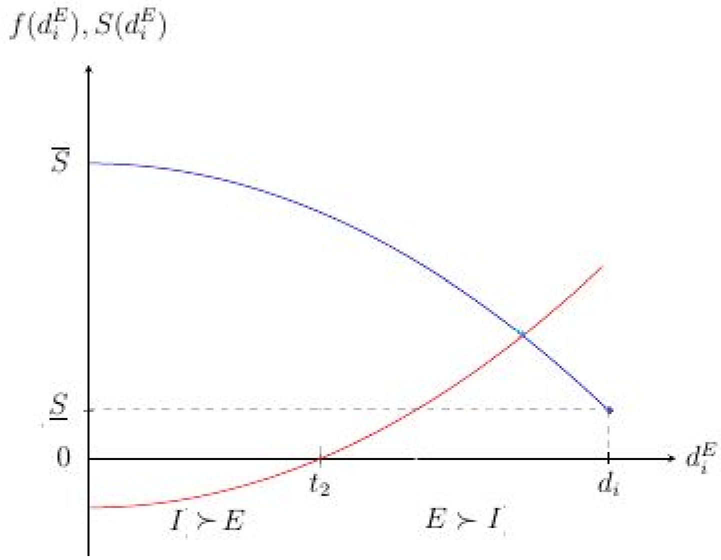
$$f(d_i^E) = (d_i^E)^2 + \alpha c d_i^E + P_I - P_E - \alpha d_i^I a - \overline{S} > 0.$$

In order to solve the inequality I assumed, that $(\frac{\alpha c}{2})^2 - P_I + P_E + \alpha d_i^I a + \overline{S} > 0$ (Assumption 1). The problem is interesting, if one of the solutions, namely t_2 is positive (i.e. when $t_2 > 0$), formally:

$$t_2 \equiv -\frac{\alpha c}{2} + \sqrt{\left(\frac{\alpha c}{2}\right)^2 - P_I + P_E + \alpha a d_i^I + \overline{S}} > 0 \qquad \forall i = 1, ..., N$$

where t_2 is the (sensible) treshold of committed costumers in the second case. As before, as the treshold grows, ceteris paribus switching to the entrant is less attractive for the old buyers. In particular, t_2 is increasing in the price of the entrant (P_E), in the maximum level of switching costs ($\overline{S}$), in the number of neighbors who does not switch, that is who keeps purchasing from the incumbent (d_i^I) and also in parameter a, keeping everything else equal. Contrarily, the treshold declines in favor of choosing the entrant, if either the price of the incumbent boosts or the payoff from coordinating on the entrant's good/network/technology (i.e. parameter c) raises, holding everything else constant. The graphical interpretation of the switching cost function $S(d_i^E)$ together with the quadratic inequality function $f(d_i^E)$ is represented in figure 2.

Figure 2: Committed buyers' treshold and switching costs



In the subsequent section I focus on four kind of (candidate) equilibrium concepts according to buyers' choice and involving firms' pricing decisions. In general, there are two types of equilibrium. In one equilibrium entry occurs, while in the other equilibrium entry does not take place at all. There are multiple reasons while the entrant does not enter the market. For instance buyers' miscoordination, switching costs or network effects. In particular, I distinguish between four pure strategy Nash (candidate) equilibriums[11]:

i. No entry equilibrium

All (new and old) buyers purchase from the incumbent (firm I), if $d_i^E < t_2$ and $d_l^E < t_l$.

[11]In an equilibrium every player plays according to her best response and no player has an incentive to unilaterally deviate from the equilibrium.

ii. Large scale entry equilibrium

Every consumer buys from the entrant (firm E), if $d_i^E > t_1$ or $d_i^E > t_2$ and $d_l^E > t_l$.

iii. Small scale entry equilibrium

The incumbent serves the old costumers while the entrant[12] supplies the new buyers, if $d_i^E < t_1$ or $d_i^E < t_2$ and $d_l^E > t_l$.

iv. Reverse small scale entry equilibrium

The entrant serves the old consumers and the incumbent sells to the new buyers, if $d_i^E > t_2$ and $d_l^E < t_l$.

In order to evaluate the candidate equilibriums just described, one crucial element of the assessment is the underlying network structure, which specifies how nodes in the network(s) are connected. In particular, the anatomy of the indirected network will have a great impact on the degree or on the degree distribution of the nodes, hence it will influence buyers' tresholds. Considering the limitations on length and also to give some welfare implications of the different candidate equilibriums from now on I assume[13], that each buyer (both old and new) are belonging to the same network and that, every node is connected to every other node excluding self-loops. In the following subsections I briefly evaluate the proposed equilibrium concepts focusing on consumer surplus, firms' profits, total welfare and also on entry. I start with reporting the features of the first two candidate equilibrium concepts, which are the two extremes from an entry point of view.

In the no entry equilibrium firm E does not enter the market, because buyers are unable to coordinate between each types (i.e. between old and new), hence this can be termed as a miscoordination equilibrium with the following characteristics. The equilibrium[14] number of consumers[15] served by the incumbent is $N_I^* = M$, while the same measure for the entrant therefore is $N_E^* = 0$. With regards to the different degrees of each player we have the following: $d_i^I = d_l^I = M - 1$, $d_i^I = d_l^I = 0 \quad \forall i, l = 1, ..., \tilde{N}, ..., N, ..., M;\ i \neq l$, where $M - 1$ indicates, that every node is connected in the network to every other node excluding herself. The equilibrium prices[16] set by the incumbent and the entrant is given

[12] Firm E is efficient enough to at least break even by only serving the unattached consumers, that is $c_E + \frac{F}{\tilde{N}} \leq c_I$.

[13] This assumption is critical altough it makes the assessment easier and more tractable. Further research can be implemented in this direction, that is applying more sophisticated and/or real network structure in order to evaluate the different candidate equilibriums.

[14] Equilibrium quantities and prices are denoted by ()*.

[15] $M = N + \tilde{N} > 2$ denotes the total number of consumers who are in the market.

[16] When setting price firm I takes away all the surplus from the new buyers and leaves some positive surplus at the attached costumers. The entrant basically could (if she would enter) set any reasonable price above her average total cost of production, but she would not attract any buyer, since buyers are unable to coordinate

by $P_I^* = \beta(M-1)a \geq c_I$ and $P_E^* \geq c_E + \frac{F}{M}$, respectively. Thus in equilibrium the profits are the following: for the incumbent $\pi_I^* = M(\beta(M-1)a - c_I)$ and for the entrant $\pi_E^* = 0$. Consumer surplus and total welfare are obtained[17] by: $CS_I^* = aN(M-1)(\alpha-\beta)$ and $W_I^* = aN(M-1)(\alpha-\beta) + M(\beta(M-1)a - c_I)$, respectively.

In the large scale entry equilibrium[18] every consumer is supplied by the entrant, that is $N_I^* = 0$, $N_E^* = M$, hence the degrees are as follows: $d_i = d_l = d_i^E = d_l^E = M-1$ and $d_i^I = d_l^I = 0$. The equilibrium prices set by the firms are given by: $P_I^* = c_I$ and $P_E^* = c_I - \underline{S}$. The equilibrium profits of the firms are $\pi_I^* = 0$ and $\pi_E^* = M(c_I - \underline{S} - c_E) - F$. Consumer surplus and total welfare are given by: $CS_E^* = N(\alpha(M-1)c - c_I) + \tilde{N}(\beta(M-1)c - c_I + \underline{S})$ and $W_E^* = N(\alpha(M-1)c - c_I) + \tilde{N}(\beta(M-1)c - c_I + \underline{S}) + M(c_I - \underline{S} - c_E) - F$, respectively. It can be shown, that with certain parameter restrictions[19] *welfare is greater under the large scale entry equilibrium, than in the no entry equilibrium* (i.e. $W_E^* > W_I^*$).

In the small scale entry equilibrium the incumbent supplies her attached costumers, whilst the entrant serves the new buyers formally: $N_I^* = N$ and $N_E^* = \tilde{N}$. Thus the degrees of the nodes are given by: $d_i^I = N-1$, $d_i^E = \tilde{N}$, $d_l^I = N$ and $d_l^E = \tilde{N}-1$. Assuming the prices set by the firms are such, that the new costumers are indifferent between the incumbent and the entrant. These prices satisfy the following: $P_I = P_E + \beta(a(M-1) - c(\tilde{N}-1))$. Nevertheless, it can be proven, that this candidate equilibrium is not constituting an equilibrium, meaning that there is at least one player (or group of players) who is able to deviate unilaterally and profitably from the characteristics of the candidate equilibrium.

Finally, let me consider the reverse small scale entry equilibrium. The name 'reverse' comes from the fact, that in this candidate equilibrium new uncommitted purchasers buy from the incumbent $N_I^* = \tilde{N}$, and old attached buyers of the incumbent switch and buy from the entrant $N_E^* = N$. The degrees of the buyers are given by: $d_i^I = \tilde{N}$, $d_i^E = N-1$, $d_l^I = \tilde{N}-1$ and $d_l^E = N$. If new buyers are indifferent between the two firms and prices satisfy the following: $P_I = P_E + \beta(a(\tilde{N}-1) - c(M-1))$, then it can be proven, that the reverse small scale entry equilibrium is indeed constitutes an equilibrium. Nonetheless, it also can be shown, that if $\overline{S}$ is sufficiently large, then no entry by firm E is not controversial with the

to buy from her.

[17] $CS^* = NU_i^* + \tilde{N}U_l^*$ and $W^* = CS^* + \pi_I^* + \pi_E^*$.

[18] This is an equilibrium when $\frac{c}{a} > \frac{N-1}{M-1}$ and $P_E \geq c_E + \frac{F}{M}$ hold.

[19] These restrictions are the following: $c_I - \underline{S} = c_E + \frac{F}{M}$, $\beta(M-1)a = c_I$ and $c = a$.

earlier parameter assumptions. In other words, *high switching costs can deter even efficient entry.*

8 Concluding remarks and policy implications

Relatively negligible events often play a significant role in an adoption or standardization process, therefore early adopters have immense power over the direction of the adoption path of a given good, service or technology. By reaching a critical mass of consumers and/or firms who adopt the entire indusrty might end up being locked in to a certain good, service or technology. Lock-in may occur, because of switching costs, network effects or buyers' miscoordination. On the supply side of lock-in firms compete fiercely for the market for creating a monopoly position. The decision between compatible or incompatible competition has an overwhelming effect on firms' profits and on consumer welfare.

Given that switching costs explain a great proportion why lock-in occurs it is reasonable to look at what are the effects of swicthing costs on the level of competition in markets and on economic welfare. In a doupoly price setting game I have examined firms' and costumers' decisions, where previously attached buyers have switching costs, that are endogenous to the number their of switching friends. According to my findings I claim the following two conlusions. Firstly, I found, that welfare is greater under large scale entry equilibrium, than under no entry equilibrium. The second main result is, that high switching costs can deter even efficient entry thus lock-in consumers to an inefficient firm's good, service or technology. According to the scientific literature, while in two-period models switching costs have an ambigous effect on welfare, infinite-horizon models tend to conclude, that switching costs have anti-competitive or consumer harming effects. Henceforth when firms choose to have switching costs via contracts or product design competition lawyers and competition policy makers should investigate in the particular case and evaluate the potential anti-competitive effects together with the efficiency gains of a certain standard or a given standardization process under rule of reason rather, than under per se (il)legality.

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