Modeling the regulatory intervention in the telecommunications market

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Abstract. This thesis discusses the role of sector-specific regulators in the rapidly changing telecommunications industry. In particular, it studies the access pricing policy which provides the optimal balance between static and dynamic efficiency that better reflects the changing regulatory goals in a highly variable economic and technological environment. In fact, there are three distinct phases in the evolution of the telecommunications markets which directly affect the optimal mixture of regulatory policy. These phases are: (i) the migration from a state monopoly market to a competitive telecommunications industry which reflects the past regulatory goal of achieving static efficiency; (ii) the migration from service-based competition over copper access networks to service-based competition over NGA networks which reflects the current regulatory goal of inducing NGA investments without distorting competition; and (iii) the migration from service-based to facilities-based competition over NGA networks which reflects the future regulatory goal of promoting dynamic efficiency. It is obvious that a different regulatory policy is required to be implemented in each migration phase in order to fulfill the desirable investment and competition outcomes. This thesis models the regulatory intervention in the telecommunications market and derives the access pricing policy that achieves the efficiency goals of each migration phase.

1 Introduction

The liberalization of the telecommunications markets in the United States (US) and Britain in the early 1980s and in Europe in the late 1990s was the result of the conventional wisdom that competition serves consumers and social welfare better than the former state monopoly, both from a short-term perspective, where entry and investment decisions are taken as given as well as from a long-term perspective, where these are treated as endogenous. However, the migration from a state monopoly market to a competitive telecommunications industry required the existence of a sector-specific regulator for the restructuring process of the telecommunications sector be-

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cause the incumbent upstream monopolist was also a supplier of the final services, and hence, there was the obvious danger that this integrated firm would seek to exclude competing providers by setting high access prices.

This fact led to a fierce debate about the terms and conditions on which competitors would have unbundled upstream access to the historical operators' local loop facilities. The reason is that regulators should achieve too many goals with only one instrument: the determination of the access charge (i.e. the price that new entrants should pay to the incumbent in order to have access to its local loop facilities). The main goals of the regulatory policy are: (i) the achievement of (static) economic efficiency, with a particular focus on improving consumers' surplus, which is achieved through low prices and high quality; and (ii) the achievement of dynamic efficiency so that investment incentives give rise to socially optimal investment decisions.

Static efficiency concerns the short-run regulatory goal to reduce the incumbent's market power in order to enable alternative operators (new entrants) to enter the market and compete effectively with the incumbent in the downstream (retail) market. Unbundling of the local loop facilitates entry by allowing new entrants to have the right to use the same network as the incumbent. As a result, both incumbent and entrants have significant incentives to invest in innovative, differentiated services. Such service-based competition promotes productive efficiency (i.e. existing assets are utilized efficiently) and allocative efficiency (i.e. existing resources are efficiently allocated to the economy). Therefore, service-based competition ensures that firms behave in a competitive manner, and hence, consumers enjoy the welfare gains from static efficiency (lower prices, better quality and extended variety of services).

On the other hand, dynamic efficiency concerns the long-run goal of access regulation to induce firms to undertake the socially optimal (efficient) investment decisions in terms of both timing of investments and the extent of network deployment. According to Bourreau and Doğan [1], facilities-based competition, which requires investments in new competing infrastructures from the incumbents and (especially) entrants, leads to efficient investment decisions and adoption of better technologies. In particular, facilities-based competition is regarded as the only means to achieve sustainable competition since it creates a level playing field between the incumbent and entrants [2-4]. Facilities-based competition achieves the full benefits of competition, and hence, consumers enjoy the full welfare gains from dynamic efficiency (maximum market growth, minimized costs, innovative technologies and services).

It is obvious that since the promotion of efficient entry is a short-run goal in the transition from state monopoly to private and competitive market structures, access regulation should indisputably aim at fostering service-based competition. In practice, both in the United States and in the European Union a light regulation with unregulated retail prices combined with *ex ante* regulation of the upstream access component has become dominant. The Telecommunications Act of 1996 [5] administered by the Federal Communications Commission (FCC) as well as the European Commission's Regulation on Local Loop Unbundling [6] mandated unbundled access to the metallic local loops of incumbent operators at cost-based prices. According to Armstrong [7], the chief benefits of cost-based access charges are two-fold. Firstly, there is no need for information about the demand for the final services. In particular, the only information needed is the cost of providing the access which is needed for all access pric-

ing policies. Secondly, cost-based access regulation is the only access pricing policy that gives the correct make-or-buy signals to entrants when bypass is a possibility.

Indeed, cost-based access regulation has led to improved service-based competition in many European countries, and hence, it seems that consumers enjoy the welfare gains from static efficiency. However, this expectation lacks of theoretical justification since academic research has focused on studying the impact of access prices on an entrant's incentives to undertake the productively efficient make-or-buy decision. This thesis contributes to the related literature by studying the conditions under which (cost-based) access prices induce the entrant to undertake the efficient make-or-buy decision in terms of both productive and allocative efficiency. This thesis shows that when the only goal of regulators is to achieve static efficiency, they should simply set the input prices at the incumbent's marginal cost of producing the upstream input since cost-based access prices lead the entrant to undertake the productively efficient make-or-buy decision which is also socially optimal [8, 9].

However, in the last decade the number of internet users as well as the capacity they demand has increased dramatically making the traditional access copper networks incapable of providing end-users with the demanded bandwidth. On the contrary, the transmission capabilities of fibre are theoretically unlimited. For this reason, the deployment of fibre access infrastructures, the so-called Next Generation Access (NGA) networks, has received significant interest among all operators since they are regarded as the only future proof solution capable to handle future demand [10]. In addition, investment in NGA networks has also attracted the interest of national governments since higher speed broadband services increase the positive impact of broadband on economic growth, productivity at the firm level, employment growth and consumers' welfare [11–14]. However, investment in NGA networks not only requires a huge initial fixed cost, but also is mainly sunk once the investment has been made. This implies that potential investors are reluctant to invest in NGA networks unless they are reimbursed for the risk they incur when investing in such networks. In other words, cost-based access prices, which are limited to boost entry and promote service-based competition within one network, discourage both incumbents and entrants to invest in new facilities as well as result in a substantial deviation from the socially desirable investment outcomes implying losses in dynamic efficiency [15].

Perhaps the most challenging task for academics, governments and policy makers is to design a regulatory policy that encourages investments in NGA networks and promotes sustainable competition. This implies that regulators aim at facilitating the migration from service-based competition over copper access networks to service-based competition over NGA networks. Therefore, the related literature focuses on proposing alternative regulatory practices which aim at achieving the current regulatory two-fold goal.

A first proposal concerns the deviation from cost-based access prices by implementing investment-contingent access charges. This thesis points out that the related literature fails to take into account the fact that it is uncertain whether the regulator will set an investment-contingent or a welfare-maximizing access price after the NGA deployment. In particular, this thesis models this fact in order to study the impact of regulatory uncertainty on an incumbent's incentives to undertake the socially optimal investments in NGA networks [16]. It is found that when the slope of the marginal investment cost function is not particularly steep in relation to the impact of invest-

ments on demand, the incumbent underinvests compared to the socially optimal investment level. On the contrary, in the more realistic case when the impact of investments on demand is low in relation to the slope of the marginal investment cost function, the incumbent may overinvest or underinvest depending on the probability of incorporating an access markup into the access price.

A second proposal concerns the deviation from the permanent regulation of access by implementing alternative regulatory regimes such as "regulatory holidays" and "sunset clauses". Particular attention has received the implementation of the "regulatory holidays" access regime, under which the investor is not imposed to any regulatory constraints for a pre-determined period of time. The reason for such particular attention is the implementation of "access holidays" in the US broadband markets and the dispute between the German government and the European Commission (EC) about the power of national legislation (which envisioned the provision of "access holidays" to the German incumbent operator) to limit the discretionary powers of the national regulator in its exclusive right to assess whether markets should be regulated or not under EU rules [17].

Obviously, such a regulatory policy provides significant investment incentives but also ambiguous outcomes in terms of social welfare. This thesis contributes to the debate about the effectiveness of "regulatory holidays" to provide efficient outcomes by studying: (i) the impact of geographic price discrimination on an unregulated monopolist's incentives to deploy a larger NGA network and on the subsequent social welfare outcomes [18]; and (ii) the optimal decision of an unregulated operator to deploy different quality NGA technologies in geographic areas which differ in their population density [19]. It is found that: (i) the regulator should allow the monopolist to geographically price discriminate as long as the investment cost is not extremely low since in this case the monopolist chooses the socially optimal pricing regime; and (ii) although a geographically differentiated NGA investment provides the unregulated monopolist with incentives to install a nationwide NGA deployment, the monopolist underinvests compared to the socially optimal levels of both quality and geographic coverage.

Even though service-based competition over NGA networks increases both static and dynamic efficiency, the full benefits of competition are only achieved by facilities-based competition. This explains why the ultimate goal of regulators is to promote dynamic efficiency which results in maximum welfare gains, maximum market growth and minimum production costs.

This thesis reviews the proposed regulatory approaches which aim to encourage access seekers to invest in their own fibre-based access networks when an initial investor has already deployed an NGA network and sustainable service-based competition has been established. In addition, a comparison of these regulatory approaches with the current regulatory framework in the European NGA market as described by the EC Recommendation shows that the proposed regulatory approaches not only fail to reflect the basic principles of the EC Recommendation, but also fail to take into account the fact that the regulatory policy applied in this phase has a direct impact on the initial investor's incentives to invest in NGA networks [20].

For this reason, this thesis also presents an innovative theoretical approach that not only reflects the current regulatory framework in the European NGA market, but also encourages the initial investor (which is assumed to be the incumbent) to invest in

NGA networks, although at the same time it incentivizes the entrants to gradually invest in their own NGA infrastructures. It is shown that the proposed approach, which is based on the basic principles governing a Credit Default Swap (CDS), provides an effective migration path towards facilities-based competition over NGA networks [20].

It is thus obvious that this thesis studies the interplay between the continuously evolving scope of telecommunications regulation and technological development by modeling the regulatory intervention and deriving the access pricing policy that achieves the efficiency goals of each migration phase.

2 Main thesis contributions

2.1 On the social optimality of make-or-buy decisions

Many economists argue that cost-based access prices encourage the right amount of entry, and hence, lead to service-based competition in the downstream market. On the contrary, Sappington [21] shows that input (or access) prices are irrelevant for an entrant's decision to make or buy an input required for downstream production when the competition between the providers in the downstream market is described by the standard Hotelling model. According to Sappington, the reason for this striking result is that previous studies fail to take into account the impact of a new entrant's make-or-buy decision on subsequent retail price competition. When the incumbent sells an upstream input to the new entrant, the incumbent faces an opportunity cost of expanding its retail output. The incorporation of this opportunity cost into the incumbent's total cost makes the incumbent act as if its upstream cost of production were equal to the specified input price. Therefore, regardless of the input price, the entrant will choose to buy (respectively, make) the upstream input whenever the incumbent (respectively, entrant) has an innate upstream cost advantage. Hence, the entrant's decision always minimizes industry costs and ensures efficient entry and utilization of the telecommunications infrastructure. Thus, the entrant always undertakes the productively efficient make-or-buy decision.

In addition, Tselekounis, Varoutas and Martakos [8] complement the work of Sappington by studying the effectiveness of input prices on inducing the entrant to undertake the socially optimal make-or-buy decision. They show that input prices do not have an impact on social welfare. The reason is that a marginal increase (decrease) in the input price causes a unit increase (decrease) in the incumbent's profits and a unit decrease (increase) in consumer surplus. As social welfare is the unweighted sum of industry profits and consumer surplus, it is thus not affected by a marginal change in input prices. Therefore, input prices are irrelevant not only for the entrant's efficient make-or-buy decision, but also for the regulator's goal to maximize social welfare. In particular, they show that regardless of the established price of the upstream input, the entrant's decision to buy (respectively, make) the upstream input from the incumbent is socially optimal when the incumbent (respectively, entrant) is the least-cost supplier of the input. As a result, in the equilibrium of the Hotelling model, the entrant un-

dertakes the efficient make-or-buy decision in terms of both productive and allocative efficiency regardless of the regulated input price.

However, these results are found to be strongly dependent on the particular model of downstream competition. Gayle and Weisman [22] consider the impact of input prices on the entrant's incentives to undertake the productively efficient make-or-buy decision under alternative downstream interactions. They show that input prices are not necessarily irrelevant in the Bertrand vertical differentiation model and are not irrelevant in the Cournot model. In addition, cost-based input prices always result in the productively efficient outcome. This implies that departure from cost-based input prices may distort the efficiency of the entrant's make-or-buy decision.

Tselekounis, Varoutas and Martakos [9] study the robustness of the result concerning the irrelevance of input prices to the entrant's incentives to undertake the productively and allocatively efficient make-or-buy decision when the downstream competition is not characterized by the Hotelling model but downstream interactions are better described by the Cournot or the Bertrand vertical differentiation competition model. They find that the social optimality of the entrant's make-or-buy decision is affected by two crucial factors: (i) the particular level of the price of the upstream input; and (ii) the cost differential between the incumbent's and the entrant's unit costs of producing the upstream input. For this reason, they obtain the range of input prices and upstream cost differential that induce the entrant to undertake the socially desirable decision. They conclude that the entrant's productively efficient make-or-buy decision is socially optimal for the set of input prices that induce the entrant to undertake the efficient decision in the case of Cournot competition and is not necessarily socially optimal in the Bertrand vertical differentiation model.

It is thus obvious that the particular model that describes the competition in the downstream market as well as each provider's efficiency in producing the upstream input have a significant impact on the social optimality of the entrant's (efficient) make-or-buy decision. This implies that regulators should have perfect information about each provider's unit cost of producing the upstream input and the way that the two providers compete in the downstream market in order to draw their optimal access pricing policy. However, when the only goal of regulators is to achieve static efficiency (e.g. in the transition from state monopoly to private and competitive market structures), they should simply set the input prices at the incumbent's marginal cost of producing the upstream input since the results of [9] show that regardless of the type of competition, cost-based access prices lead the entrant to undertake the productively efficient make-or-buy decision which is also socially optimal.

2.2 Investments in Next Generation Access infrastructures under regulatory uncertainty

The related literature discusses the effectiveness of two different regulatory approaches on the regulator's current goal to achieve the socially efficient investment level when it sets the access price after the investment decision of the incumbent. The first approach supports that the regulator sets a particular investment-contingent access price, which compensates the incumbent for the investment risks, in order to

provide significant investment incentives. On the contrary, the second approach argues that the regulator deviates from such *ex ante* known access price (once the investments are in place) by setting the access price at the marginal cost of providing the access in order to maximize social welfare.

Tselekounis and Varoutas [16] modeled the more realistic case in which the regulator sets the access price at the marginal cost of providing the access with some probability and gives an access markup, which equals the average cost of the investments, with the complementary probability. Therefore, it is uncertain which of the two assumptions made in the related literature will prevail when the new access infrastructures are in place.

A non-commitment setting is used in order to take account for regulatory uncertainty. In addition, the retail (downstream) market is characterized as an unregulated duopoly market in which the incumbent and the entrant choose quantities simultaneously and independently (i.e. firms compete á la Cournot). The level of NGA investment undertaken by the incumbent leads to an outward parallel shift in the demand, and hence, NGA investments have a positive impact on the demand for the new fibre-based services. Furthermore, the incumbent faces a quadratic NGA investment cost function with respect to the investment level implying that the slope of the marginal investment cost function is linear and increasing in the investment level.

The privately and the socially optimal investment levels are derived as a function of the probability $\alpha \in [0,1]$ of incorporating into the access price an access markup, which equals the average cost of the investments, in order to fully compensate the incumbent for the NGA investment risk. A first significant finding is that a marginal increase in such probability positively affects the private investment incentives and negatively affects the socially optimal investments. The comparison of the privately and the socially optimal investment levels show that there is a unique positive value $\tilde{\alpha}$ of the probability of incorporating into the access price an access markup which induces the incumbent to undertake the socially optimal investments. If $\alpha > \tilde{\alpha}$ (respectively, $\alpha < \tilde{\alpha}$), the NGA investment level chosen by the incumbent is higher (respectively, lower) than the socially optimal one. This implies that any deviation from the socially optimal investment level leads to welfare losses.

A second significant result is that the derived value of $\tilde{\alpha}$ is significantly affected by the impact of the investments on demand and the slope of the marginal investment cost function. In particular, the value of $\tilde{\alpha}$ is positively affected by an increase in the impact of investments on demand and negatively affected by an increase in the slope of the marginal investment cost function (ceteris paribus). This implies that, for a given slope, higher consumers' valuation for the NGA services results in higher $\tilde{\alpha}$, which in turn leads to higher efficient investment levels. In other words, higher consumer consumers' valuation for the NGA services makes the investments more socially desirable, and hence, the socially optimal investment level is achieved for a higher probability of compensating the incumbent for the investment risks. This result positively affects the incumbent's investment incentives, and hence, the achieved efficient investment level increases as well.

On the contrary, for a given positive impact of the investments on demand, a steeper slope of the marginal investment cost function leads to lower values of $\tilde{\alpha}$. This implies that as the NGA investment becomes marginally more expensive, the society is better off by a lower NGA deployment which is achieved by a higher probability of

setting the access price at the marginal cost of providing the access. Therefore, the efficient NGA investment level is achieved for lower values of $\tilde{\alpha}$.

Combining the two aforementioned significant results leads to the main result of Tselekounis and Varoutas [16]:

(i) When the slope of the marginal investment cost function is not particularly steep in relation to the positive impact of investments on demand, the incumbent always underinvests compared to the socially optimal investment level. The reason is that the critical value of the probability of including an access markup into the access price ($\tilde{\alpha}$) is higher that 1. This implies that the socially desirable outcome cannot be achieved even if the regulator commits to an access price scheme that includes an access markup equal to the average cost of the investments. In this case, a higher access markup which leads to $\tilde{\alpha} \leq 1$ seems to be socially desirable.

(ii) On the contrary, in the more realistic case when the impact of investments on demand is low in relation to the slope of the marginal investment cost function, the incumbent may overinvest or underinvest depending on the probability of incorporating an access markup into the access price. In this case $\tilde{\alpha} \in (0,1)$, and hence, the incumbent overinvests for high probability of incorporating an access markup into the access price and underinvests for low probability values. As a result, the optimal social welfare outcome cannot be achieved with the incumbent's profit maximizing investment level when $\alpha \neq \tilde{\alpha}$. This implies that regulatory uncertainty significantly affects the incumbent's incentives to undertake the socially optimal investments in NGA networks.

2.3 A CDS approach to induce facilities-based competition over NGA networks

Tselekounis, Varoutas and Martakos [20] propose an innovative approach that reflects the current regulatory framework in the European NGA market as described by the EC Recommendation. In particular, the proposed approach models the basic principles of the EC Recommendation and then assesses its effectiveness on inducing facilities-based competition over NGA networks. This implies that this approach can be included in the literature that departs from assessing the efficiency outcomes of the regulation of the copper access networks. The aim of the proposed approach is to meet the current and the future regulatory goals by tackling the initial trade-off between encouraging the incumbents to invest in NGA networks and fostering competition, while incentivizing the entrants to gradually climb the ladder of investment when the NGA investment is proven to be successful. Therefore, the proposed approach provides a theoretical approach to encourage the deployment of a nationwide NGA network (i.e. maximize the potential investment outcome in terms of geographic coverage) with the ambition to finally reflect the socially desirable choice as reflecting in an effective migration path towards facilities-based competition over NGA networks.

The structure and the implementation of the proposed approach are based on the basic principles governing a Credit Default Swap (CDS). A CDS contract is an agreement between two parties, the protection buyer and the protection seller. The first party to the contract, the protection buyer, wishes to insure against the possibility of default on a bond issued by a particular company. The company that has issued the bond is called the reference entity. The second party to the contract, the protection

seller, is willing to bear the risk associated with default by the reference entity. The protection buyer of the CDS makes a series of payments (the CDS "fee" or "spread") to the protection seller and, in exchange, receives a payoff in the event of a default by the reference entity. If a default does not occur over the life of the contract, the contract expires at its maturity date, and hence, the protection seller does not make any payments to the protection buyer.

In an NGA context, the incumbent, which invests in NGA networks, and the regulator agree on a business plan that allows the incumbent to recover the investment in a nationwide NGA deployment during a certain period of time. If the investment has not been recovered at the end of this period, the regulator commits itself that it will compensate the incumbent for the unrecovered part of the investment. After the end of this period, no regulatory remedies will be imposed to the incumbent (sunset clause). In exchange, the incumbent should make periodic payments to the regulator. However, the regulator chooses to subtract this amount from the payments that an access seeker makes to the incumbent in order to have access to the NGA networks. This implies that the incumbent does not pay a periodic fee to the regulator but he subtracts this amount from the access payments he receives. If, however, the investment has been recovered before the end of the clause, the regulator does not make any payment to the incumbent, the incumbent stops making indirect periodic payments to the access seeker and no remedies imposed to the incumbent. In such contract, the incumbent is the protection buyer and the regulator is the protection seller which will compensate the incumbent in the case of a default event (i.e. if the investment has not been recovered at the end of the pre-determined period).

In addition, the model proposes that the contract commits the regulator to apply a certain policy during the whole pre-determined period. This policy, which concerns the derivation of the access pricing formula as well as its evolution over time, is known to the incumbent *ex ante*. In particular:

At time $t=0$ the incumbent and the regulator agree on a business plan that allows the former to have recovered the investment in NGA networks at time $t=T$ with a given probability. Or, in other words, they estimate the probability of default (P_0) as well as the corresponding unrecovered part of the investment (X_0) at the end of the pre-determined period. The subscript "0" denotes the values of the parameters P_t and X_t, $t \in [0,T]$, at the time that the estimation takes place (i.e. $t=0$ in this case). Based on the estimated values of X_0 and P_0, they assess the amount of the periodic payments (K_0) that the incumbent should make to the regulator. This implies that if the estimated demand parameters at $t=0$ coincide with the actual ones during the whole predetermined period *T*, the total amount of the periodic payments will be TK_0. However, the regulator chooses to not receive such payments but to subtract this amount from the access payments. Therefore, the reduced access payments that the entrant will finally make to the incumbent from $t=0$ to $t=T$ are given by:

$$AP_{0-T} = W_C \sum_{t=0}^{t=T} Q_t^E - TK_0 \tag{1}$$

or

$$AP_{0-T} = (W_C - R_o) \sum_{t=0}^{t=T} Q_t^E \tag{2}$$

where W_C denotes the cost-based access price, Q_t^E represents the estimated number of consumers served by the entrant at time t and R_0 is a regulatory parameter such that

$$R_0 \sum_{t=0}^{t=T} Q_t^E = TK_0 \tag{3}$$

Therefore, the access price that the entrant pays to the incumbent during the T years is given by $W_0 = (W_C - R_o)$. However, the regulator reviews this access price at pre-determined periods. In each periodic review the regulator may increase or decrease the access price according to whether the NGA investment (at the time of each review) is more successful (i.e. an upside case) or less successful (i.e. a downside case) than the initial estimations.

It is shown that in an upside (respectively, downside) case, the implementation of the basic principles governing a CDS contract requires a proper increase (respectively, decrease) in the access price through a proper decrease (respectively, increase) in the regulatory parameter R_0. Therefore, an endogenous access pricing rule encourages the entrants to climb the ladder of investment in each upside case. On the contrary, such endogenous access pricing rule provides the entrants with disincentives to invest in each downside case. However, in the latter case, the regulator's goal is to increase the total demand rather than to incentivize the entrant to invest in NGA networks. The reason is that the entrant invests in NGA networks only when the NGA investment is successful. Therefore, the regulator should first promote the success of the NGA investment and then encourage the entrant to invest in its own facilities. It is obvious that in the downside cases the proposed approach fulfills in enhancing the diffusion process since a lower access price facilitates service-based competition over NGA networks. As a result, such an access pricing policy increases the probability of an upside case in the next regulatory review.

Therefore, the proposed approach will eventually lead to the recovery of the NGA investment at the end of the pre-determined period or even earlier. This implies that although its limitations and its potential implementation shortcomings, the proposed approach, which is based on the basic principles governing a Credit Default Swap (CDS), tackles the initial trade-off between encouraging the incumbent to invest in NGA networks and fostering competition, while it incentivizes the entrant to gradually climb the ladder of investment. As a result, the proposed approach represents an effective path towards facilities-based competition over NGA networks.

3 CONCLUSIONS

The telecommunications industry is the most rapidly evolving network industry since it has undergone extensive changes in recent decades. Although these changes are mainly related to technological advancements, the regulatory policy has played a significant role in the promotion of competition and innovation. This thesis models the regulatory intervention in the telecommunications market and derives the access pricing policy that achieves the efficiency goals in each of the three major migration phases in the structure of the telecommunications industry.

Firstly, the framework during the migration from a state monopoly market to a competitive telecommunications industry is modeled in order to study the impact of

access prices on the entrant's incentives to undertake the efficient make-or-buy decision in terms of both productive and allocative efficiency. It is found that the particular model of competition that describes the competition in the retail market significantly affects the effectiveness of access prices to achieve static efficiency. However, cost-based access regulation, which has been widely adopted by the regulatory authorities, is found to promote both productive and allocative efficiency regardless of the competition conditions. Therefore, theoretical modeling shows that usage cost-based prices achieve the past regulatory goal concerning the promotion of static efficiency.

Secondly, this thesis reviews the research articles which study the effectiveness of cost-based access prices on achieving the current regulatory goal to promote service-based competition over NGA. The related literature concludes that mandating access to NGA networks at usage cost-based prices discourages both incumbents and entrants to invest in such networks. Therefore, the research focuses on studying alternative regulatory schemes that may promote both investments and competition. The most significant deviation from the permanent regulation of access at usage cost-based prices concerns the implementation of non-cost-based access prices.

The related literature concludes that investment-contingent access prices can induce the incumbent to undertake to socially optimal investments in NGA networks (i.e. promote both static and dynamic efficiency) under certain conditions concerning the demand and cost structure. However, these studies do not take into account the fact that regulators have significant incentives to deviate from such schemes once NGA networks have been deployed by setting a cost-based access price in order to maximize social welfare. This thesis models this fact in order to study the impact of regulatory uncertainty on an incumbent's incentives to undertake the efficient investments in NGA networks. It is found that the feasibility of the socially optimal outcome is not only affected by the demand and cost structure, but also by the perceived regulatory uncertainty.

Thirdly, this thesis points out that the current and the future regulatory goal of promoting dynamic efficiency through facilities-based competition are closely related, and hence, a combined regulatory policy should be applied. As a result, it proposes an innovative regulatory approach which is based on the basic principles governing a CDS contract. It is shown that under quite general but plausible assumptions about demand and cost factors, the proposed approach can induce an efficient migration towards facilities-based competition over NGA networks. It is thus obvious that this thesis not only discusses the past, the present and the future state of telecommunications networks, but also significantly contributes to the literature which studies the optimal access pricing policy that achieves the past, the current and the future regulatory goals.

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