NGA Investment Incentives under Geographic Price Discrimination

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ABSTRACT

This paper compares the impact of retail price discrimination and uniform pricing on a monopolist's incentives to extend its Next Generation Access (NGA) network deployment to less densely populated geographic areas. It is found that geographic price discrimination provides the monopolist with higher incentives to deploy a larger NGA network. In addition, geographic price discrimination results in better welfare outcomes than uniform pricing as long as the investment cost is not extremely low. In such cases, the regulator should allow the monopolist to geographically price discriminate since the monopolist chooses the socially optimal pricing regime.

Keywords: geographic markets, investment incentives, next generation access networks, price discrimination, social welfare

JEL classification: L43, L51, L96

1. Introduction

During the last decade, the number of Internet users, as well as, the capacity they demand have increased spectacularly. As a result, the increasing transmitted volume of data has made the traditional access copper networks incapable of providing end-users with the demanded bandwidth. On the contrary, access networks based on optical fibre are the only future proof solution capable to satisfy the future demand (Shumate, 2008) since the transmission capabilities of fibre are theoretically unlimited providing high data rates, low loss and low distortion. Such fibre-based access networks are widely known as Next Generation Access (NGA) networks.

Not only technical reasons but also economic ones make the need for investments in NGA networks imperative. In particular, it is found that investments in broadband infrastructures have an undisputable positive effect on economic growth, broadband diffusion and job creation (Czernich et al., 2011; ITU, 2012). These results partially interpret why national governments rank among their top priorities the encouragement of investments in NGA networks.

Nevertheless, a number of features of NGA networks make investments principally challenging. Demand uncertainty is particularly problematic because of the substantial sunk investment cost. In addition, there has been an ongoing discussion on the outcomes of potential regulatory intervention, especially with regard to its impact on investment and competition outcomes. According to several studies (Charalampopoulos et al., 2011; Nitsche and Wiethaus, 2011), permanent or temporary absence of access regulation (regulatory forbearance or holidays, respectively) appear superior to other regulatory regimes in terms of both NGA investment level and the timing of investments, although they result in ambiguous outcomes in terms of social welfare.

Recently, there has also been a growing discussion supporting regulatory forbearance in certain geographic areas as a means of stimulating NGA investments (ERG, 2008). This could lead to geographic de-averaging of prices that would reflect the geographic variances in market conditions, which may significantly differ from traditional PSTN/DSL conditions. Indeed, after a period of obligation of non-discrimination (EU, 2002), currently, price discrimination is allowed to a certain (at least wholesale) extent related to NGA networks in Europe in order to foster innovation and welfare growth by promoting investments (EC, 2010). Thus, there may be a case for designing remedies that can vary across geographic markets that would be defined as locations with e.g., homogeneity in willingness to pay, competitive conditions, cost, etc. Such practice is widely known as price discrimination which can be defined as selling the same product to different customers at different prices even if the cost of sale is the same to each other (Posner, 2001).

Concerning the prospective consumers' reaction to the launch of NGA-based services, it is expected that there will be a significant variation among consumers' willingness to pay for the additional benefits of such enhanced services. This implies that some end-users, which have low willingness to pay, will still buy the basic "universal-level" service only, while some others have higher valuation for advanced bandwidth-hungry services, and hence, will migrate to the NGA networks. The main take-away of the relevant studies (Flamm and Chaudhuri, 2007; Preston et al., 2007) is that consumers who place a higher (lower) valuation to broadband subscription tend to live in higher (lower) densely populated areas. Under a geographic price discrimination perspective the operator could exploit such information and be able to price-discriminate in order to reflect more closely retail consumers' willingness to pay ("value-based" pricing) and/or geographical differences in network costs.

Academic research points out that price discrimination increases producer surplus while the outcomes on consumer surplus and social welfare are heterogeneous. Varian (1985) shows that a necessary condition for price discrimination to improve welfare is that output increases. More recent articles study the impact of price discrimination not only on welfare outcomes, but also on a monopolist's investment incentives. In particular, these recent articles study the impact of price discrimination on the level of investment in quality (Alexandrov and Deb, 2012; Valletti, 2006). In both articles the number of the markets that the quality-enhanced product will be sold is exogenously defined, whereas the investment in quality is endogenously derived. It is found that price discrimination results in more investment in quality than uniform pricing, whereas its impact on social welfare depends on the specific underlying industry characteristics.

Contrary to the above-mentioned articles, this paper studies the impact of price discrimination on the geographic level of NGA deployment chosen by a monopolist. This implies that the quality of an NGA-based service is exogenously defined (e.g., FTTH), whereas the number of geographic areas (markets) that this service will be provided is endogenously chosen. It is found that that geographic price discrimination provides the monopolist with higher incentives to deploy a larger NGA network. In addition, geographic price discrimination results in better welfare outcomes than uniform pricing as long as the investment cost is not extremely low. The policy implication from these results is that an unregulated monopolist will choose the socially optimal pricing regime as long as the investment cost is not extremely low.

The rest of the paper is as follows. Section 2 presents the model. Section 3 compares two pricing regimes, differential and uniform pricing, in terms of investment incentives and the subsequent social welfare level. The last section summarizes the main results of this article and proposes the directions for future work.

2. The model

Assume a hypothetical country consisting of different geographic areas which can be indexed in a decreasing order according to their population density. In particular, geographic areas are indexed by i with $i \in [1, n]$, where low values of i imply geographic areas with high population density, whereas geographic areas that are indexed by i close to n represent rural areas (i.e., with low population density). A monopolist provides a basic "universal-level" broadband service (e.g., ADSL) to all geographic areas at a uniform price.

Now assume that the monopolist invests in access network upgrade in order to provide a certain ultra-fast NGA-based service to the consumers (i.e., FTTH). The monopolist determines the geographic extent of the NGA deployment denoted by $x \in [1, n]$. A larger x reflects a fibre deployment to less densely populated geographic areas. The monopolist faces a quadratic NGA investment cost with respect to x, given by $c(x) = \varphi x^2 / 2$. The parameter $\varphi > 0$ represents the slope of the marginal investment cost function, and hence, higher values of φ imply a higher investment cost for a given investment level. The convex form reflects the fact that fibre deployment becomes marginally more expensive as it is extended to rural, less densely populated areas. It is further assumed that the NGA investment level does not have any impact on the marginal cost of providing the NGA-based service. Thus, the unit costs of production and distribution are set to zero.

In addition, the NGA deployment positively affects the willingness to pay of all consumers e.g., due to the emerging positive network effects. However, as it has already been noted in the introduction section, the consumers who live in more densely populated areas place a higher valuation to the additional benefits stemming from the NGA-based services than the consumers who live in less densely populated areas. In particular, it is assumed that the impact of the NGA deployment on the consumers' willingness to pay is given by (x/i^2). Therefore, the demand function in each geographic area i is given by:

$$q_i = A + x/i^2 - p_i \qquad (1)$$

where p_i and q_i are the retail market price and the quantity supplied by the monopolist, respectively, in each geographic area. The parameter A represents the point at which the inverse demand function, $p_i = A + x/i^2 - q_i$, intersects the vertical (price) axis when no investments have taken place. This implies that A represents the maximum valuation that the consumers place to the basic "universal-level" service, which affects the overall valuation for this service. As a result, the profit function of the monopolist in each geographic area is given by:

$$\Pi_i = p_i(A + x/i^2 - p_i) \qquad (2)$$

whereas, the total profits of the monopolist are given by:

$$\Pi = \int_1^x p_i(A + x/i^2 - p_i)di - (\varphi x^2/2) \qquad (3)$$

A two-stage game is considered. In the first stage, the monopolist determines the extent of the NGA deployment, whereas in the second stage, it provides the exogenously determined quality of the NGA-based service in the geographic areas where the NGA network has been deployed and sets the price(s) according to the chosen pricing regime. In particular, there are two possible pricing regimes. Under the first pricing regime, the monopolist sets a different retail price to each geographic area (differential pricing) which reflects the different impact of the NGA deployment on the willingness to pay of the consumers who live in different geographic areas. According to the second one, the monopolist sets the same retail price (uniform pricing) to all geographic areas.

3. Investment and welfare outcomes

This section compares the two pricing regimes in terms of investment incentives and social welfare. In both cases, the game is solved backwards. This implies that in the second stage, the investment cost is sunk and the monopolist sets the price(s) of the ultra-fast broadband service for a given level of NGA deployment chosen in the first stage.

3.1. Differential pricing

In each geographic area, the monopolist sets the retail price that maximizes its profits. Taking the first order condition of (2) with respect to p_i yields the optimal regional retail prices as a function of the investment level x:

$$p_i = \frac{A}{2} + \frac{x}{2i^2} \tag{4}$$

Substituting (4) into (1) gives the quantity demanded (number of subscribers) in each geographic area:

$$q_i = \frac{A}{2} + \frac{x}{2i^2} \tag{5}$$

Therefore, the total profits of the monopolist and the consumer surplus are given, respectively, by:

$$\Pi^d = \int_1^x \left(\frac{A}{2} + \frac{x}{2i^2} \right)^2 di - \frac{\varphi x^2}{2} = (x-1)(3A^2x + 6Ax + x^2 + x + 1)/(12x) - (\varphi x^2/2) \tag{6}$$

$$CS^d = \int_1^x \frac{q_i^2}{2} di = (x-1)(3A^2x + 6Ax + x^2 + x + 1)/(24x) \tag{7}$$

Taking the first order condition of (6) with respect to x gives the optimal investment level chosen by the monopolist under price discrimination:

$$x^d = \frac{y}{3z} + v + \frac{y^2}{9z^2v} \tag{8}$$

where:

$$y = 3A^2 + 6A \tag{9}$$

$$z = 12\varphi - 2 \tag{10}$$

$$v = \left\{ \sqrt{\left[\left(\frac{y}{3z} \right)^3 + \frac{1}{2z} \right]^2 - \left(\frac{y}{3z} \right)^6} + \left(\frac{y}{3z} \right)^3 + \frac{1}{2z} \right\}^{1/3} \tag{11}$$

This investment level reflects the less densely populated geographic area which is passed by NGA network. Substituting (8) into (6) gives the monopolist's profits from all NGA geographic areas passed (Π^d), whereas consumer surplus (CS^d) is derived by substituting (8) into (7). Social welfare (W^d) is the unweighted sum of profits and consumer surplus.

3.2. Uniform pricing

In this pricing regime, the monopolist sets the same price, p, in each geographic area. This implies that the demand function in each geographic area i is $q_i = A + x/i^2 - p$, and hence, the total demand faced by the monopolist is given by:

$$q = \int_1^x q_i \, di = (x-1)(A+1-p) \tag{12}$$

Therefore, the total profits of the monopolist are given by:

$$\Pi^u = pq - (\varphi x^2 / 2) = p(x-1)(A+1-p) - (\varphi x^2 / 2) \tag{13}$$

Taking the first order condition of (13) with respect to p yields the optimal retail price:

$$p = (A+1)/2 \tag{14}$$

As a result, the quantity demanded (number of subscribers) in each geographic area is given by:

$$q_i = (x-1)(A+1)/2 \tag{15}$$

Therefore, the total profits of the monopolist and the consumer surplus are given, respectively, by:

$$\Pi^u = (x-1)(A+1)^2 / 4 - (\varphi x^2 / 2) \tag{16}$$

$$CS^u = \int_1^x \frac{q_i^2}{2} di = (x-1)(3A^2 x + 6Ax + 4x^2 - 5x + 4) / (24x) \tag{17}$$

Taking the first order condition of (16) with respect to x yields the optimal investment level chosen by the monopolist under uniform pricing:

$$x^u = \frac{(A+1)^2}{4\varphi} \tag{18}$$

Substituting (18) into (16) gives the monopolist's profits from all NGA geographic areas passed (Π^u), whereas consumer surplus (CS^u) is derived by substituting (18) into (17). Social welfare (W^u) is the unweighted sum of profits and consumer surplus.

3.3. Comparison of the pricing regimes

This section compares the two pricing regimes in terms of investment incentives and social welfare. It is obvious that the complex form of (8), which gives the optimal investment level under differential pricing, makes the comparison of the investment levels derived by differential and uniform pricing extremely difficult without providing much critical appraisal. In addition, both the monopolist's profits and consumer surplus are significantly affected by the chosen investment levels, and hence, the comparison of the social welfare levels under each pricing regime is also extremely difficult in a theoretical way. Thus, numerical simulations are used in order to compare the two pricing regimes in terms of investment incentives and social welfare.

There are two independent parameters, A and φ. Therefore, this paper studies the impact of such parameters on the effectiveness of each pricing regime to induce higher levels of both investments and social welfare. It is obvious that the study focuses on the range of the parameters that leads to non-negative profits for the monopolist under both regimes. In particular, differential pricing leads to non-negative profits for $\underline{\varphi}^d \le \varphi \le \overline{\varphi}^d$, whereas, under uniform pricing, the monopolist's profits are non-negative for $\varphi \le \overline{\varphi}^u$. These critical values of φ are affected by a change in A according to the following Table.

Table 1. The critical values of φ for different values of A

A	$\underline{\varphi}^d$	$\overline{\varphi}^d$	$\overline{\varphi}^u$	φ^x	φ^W
5	0.605	8.469	4.500	9.045	0.878
10	0.589	29.740	15.125	30.424	0.868
15	0.586	63.490	32.000	63.071	0.866
20	0.584	109.740	55.125	110.865	0.865
25	0.584	168.490	84.500	172.419	0.865
30	0.584	239.740	120.125	236.401	0.865

It is obvious that $\overline{\varphi}^u < \overline{\varphi}^d$ for all values of A, and hence, the range that leads the monopolist to earn non-negative profits under both pricing regimes is $\underline{\varphi}^d \le \varphi \le \overline{\varphi}^u$. Figure 1 shows the impact of A and φ on the investment levels undertaken by the monopolist under each pricing regime for $A=5$, $A=10$, $A=15$ and $A=20$.

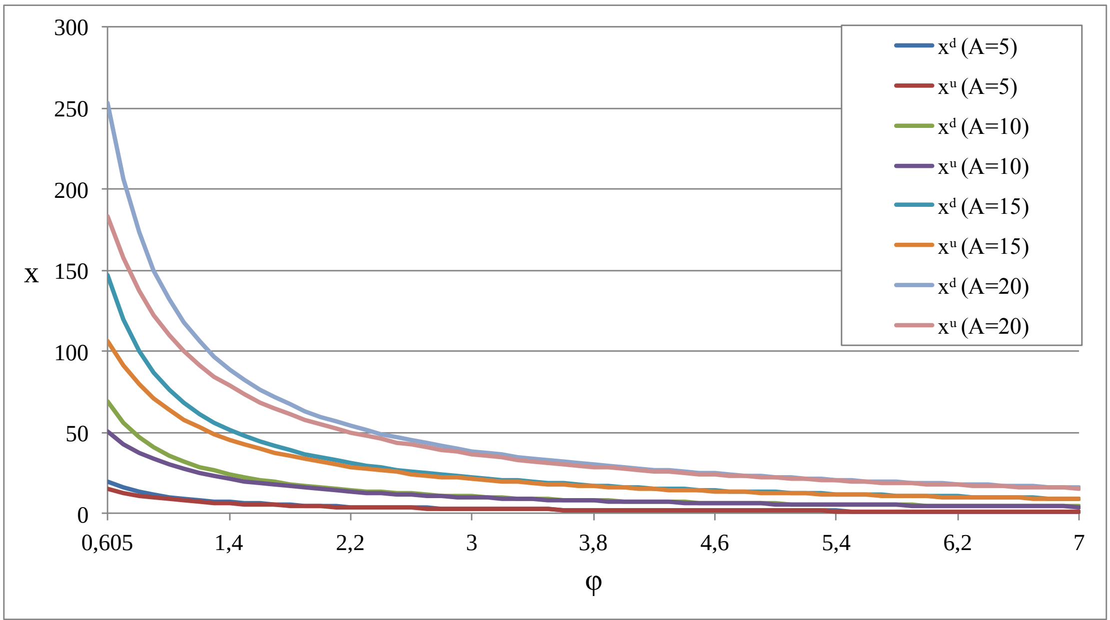

Figure 1. The levels of NGA deployment under differential and uniform pricing as a function of φ for different values of A

From figure 1 it can be deduced that for any given value of A, an increase in φ leads the monopolist to undertake a lower NGA deployment either under differential or uniform pricing regime. This implies that as the investment cost increases, the monopolist has lower incentives to invest in NGA networks. In addition, an increase in A shifts the investment function upwards, which implies that, given a particular investment cost parameter φ, higher valuation for the basic "universal-level" broadband service leads to higher investment levels. It is thus obvious that an increase in φ negatively affects both investment levels, whereas an increase in A positively affects the monopolist's investment incentives. Not surprisingly, the monopolist has higher incentives to deploy a larger NGA network for low investment cost and high valuation for the basic "universal-level" broadband service.

Concerning the impact of A and φ on the effectiveness of each pricing regime to induce higher investment level, simulations show that differential pricing leads to higher investment level than uniform pricing as long as $\varphi \neq \varphi^x$. When $\varphi = \varphi^x$, the two pricing regimes result in the same outcome in terms of NGA deployment (i.e., $x^d = x^u$). Table 1 also provides the values of φ^x for different values of A. It is obvious that φ^x is always higher than the upper limit of φ (denoted by $\overline{\varphi}^u$) that makes the monopolist earn non-negative profits under both pricing regime. Therefore, the following proposition can be stated:

Proposition 1. *For any admissible values of A and φ, differential pricing always results in higher investment levels than uniform pricing (i.e., $x^d > x^u$).*

The main regulatory implication stemming from the above proposition is that the regulator should allow the monopolist to geographically price discriminate if its unique purpose is to promote investments in NGA networks. However, the goal of regulators is not only to encourage NGA investments but also to prevent the monopolist from exploiting its market power to the detriment of consumers. In other words, the regulator should allow the monopolist to geographically price discriminate if such regime results in better outcomes than uniform pricing in terms of both investment incentives and social welfare. Figure 2 shows the impact of A and φ on the subsequent social welfare levels derived by the monopolist's optimal investment choice under each pricing regime for $A=5$, $A=10$, $A=15$ and $A=20$.

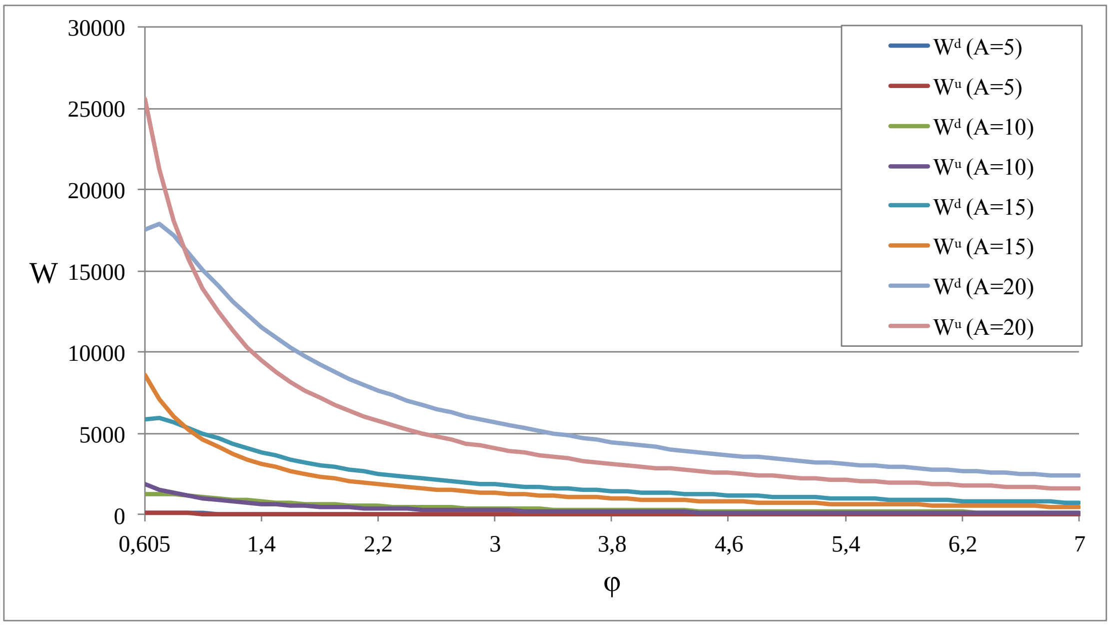

Figure 2. The levels of social welfare under differential and uniform pricing as a function of φ for different values of A

It is obvious that the behavior of the welfare functions is similar to that of investments. In particular, an increase in A has a positive impact on the welfare levels derived by both pricing regimes, whereas an increase in the investment cost φ negatively affects the social welfare outcomes. Concerning the comparison between the derived social welfare levels under each pricing regime, simulations show that differential pricing leads to better welfare outcomes than uniform pricing as long as $\varphi > \varphi^W$. On the contrary, when $\varphi < \varphi^W$, the socially optimal pricing regime is that of uniform pricing. Therefore, for every value of A, there is a critical value of φ denoted by φ^W that makes $W^d = W^u$. This fact is clearly depicted in figure 2, whereas Table 1 provides the particular values of φ^W for different values of A.

Note that the values of φ^W are very close to that of $\underline{\varphi}^d$ implying that there is a very limited range of φ that makes $W^u > W^d$ hold. In other words, when $\underline{\varphi}^d \leq \varphi < \varphi^W$, uniform pricing is the socially optimal pricing regime. In this case, there is a trade-off between encouraging the monopolist to deploy a larger NGA network and preventing the monopolist from exploiting its market power. However, when $\varphi > \varphi^W$, differential pricing leads to better outcomes than uniform pricing in terms of both investments and social welfare. Given that the particular value of φ^W is rather low and the range of φ that makes $W^u > W^d$ hold is rather limited, the following proposition can be stated:

Proposition 2. *The regulator should allow the monopolist to geographically price discriminate as long as the investment cost is not extremely low.*

As a result, geographic price discrimination in NGA markets should be allowed by the regulator when the investment cost is not extremely low. In this case, the monopolist will price the NGA-based services according to the socially optimal pricing regime, which is the differential pricing. On the contrary, when the investment cost is extremely low (i.e., $\underline{\varphi}^d \leq \varphi < \varphi^W$), there is a trade-off between encouraging investments and promoting social welfare. In this case, the regulator may oblige a uniform pricing in order to improve social welfare since investments in access infrastructures may have already been encouraged by allowing the monopolist to ban access to the new NGA infrastructures by alternative operators (these are the cases of regulatory forbearance or regulatory holidays).

4. Conclusions

This paper discussed the impact of retail price discrimination on investment incentives and social welfare when the investor is not obliged to provide access to its improved access infrastructures to its competitors. In particular, it was assumed that the firm invests in NGA networks under regulatory forbearance or regulatory holiday. Thus, the investor firm acts as a monopolist in the market for ultra-fast broadband services provided over the new fibre-based access network. It was further assumed that the consumers place a different valuation to the ultra-fast broadband connection according to their geographic area. In particular, consumers who live in more densely populated areas place a higher valuation to the ultra-fast broadband service due to socioeconomic characteristics, such as income, education, etc.

It was found that geographic price discrimination provides the monopolist with higher incentives to deploy a larger NGA network (i.e., the NGA investment is extended to rural, less densely populated areas). In addition, geographic price discrimination results in better welfare outcomes than uniform pricing as long as the investment cost is not extremely low. In such cases, the regulator should allow the monopolist to geographically price discriminate since the monopolist chooses the socially optimal pricing regime. On the contrary, when the investment cost is extremely low, uniform pricing is the socially optimal pricing regime, whereas differential pricing maximizes private investment incentives. In such cases, a benevolent regulator may impose the uniform pricing regime in order to mitigate the detrimental impact of regulatory forbearance or holidays on social welfare.

Although its limitations, this paper provided some very interesting results concerning the regulation of the retail NGA market. However, since the focus of regulators is continuously shifting from the regulation of the retail market to the regulation of the wholesale market, this paper can trigger a discussion on the investment and welfare outcomes of geographic price discrimination at a wholesale level. Thus, future research should focus on improving this paper by introducing competition both for investments and consumers, and then, studying the regulatory implications of a geographic differentiated access price.

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