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**Input price discrimination with heterogenous
sub-markets**

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Input price discrimination with heterogenous sub-markets

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Abstract

The objective of the paper is to analyse optimal prices for an input monopolist in the presence of asymmetric information about the size of the sub-markets, and when the sub-markets may provide either substitute or complementary products to the input provider's own downstream subsidiary. The downstream firms produce products that may be vertically differentiated, but the degree of vertical differentiation is assumed to be private knowledge to the downstream firms.

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1 Introduction

In communications markets, the emergence of digital networks has resulted in the digital distribution network taking over a number of services that was currently performed by specialised networks and it is often argued that this development will continue even further. Digital distribution networks serve voice and data services, the distribution of newspapers, the distribution of books and academic journals, and TV-signals. The costs associated with setting up such networks are often very high,

whereas the cost of distributing an extra byte of information, or digital signals, is almost non-existent. Consequently, it makes sense from an efficiency point of view to pool network resources with one or a small number of providers, and seek to utilise these networks efficiently. This technological convergence implies that firms that use (digital) distribution networks as an input may compete in the same market for the same consumers, or they may operate in adjacent markets where products may be either substitutes or complements. Typically, the owners of the distribution networks are also active in vertically related markets, but may or may not compete directly with the other downstream firms who purchase network inputs.

The challenge for public policy is then how to incorporate the fact that the usage of the distribution network may differ between access seekers. The role of the present paper is to analyse the situation where a monopolist sells its output as an (essential) input for other firms in the value chain, and the assumption is that the role of public policy is restricted to requiring that access is provided at fair terms and no restrictions are put on neither the pricing structure nor the price level. EU Regulation No. 2887/2000 on unbundled access to the local loop states that all reasonable requests for access to the local loop should be met by operators with significant market power in their respective markets (this is interpreted as a market share over 25%). It further states that the costing and pricing should be transparent, non-discriminatory and ensure fairness. In addition, access should be granted to independent access seekers at the same terms as is offered to its own subsidiaries. Some degree of differentiation in the offers to access seekers is allowed in Article 10 of the Access Directive, where it is stated that "the operator applies similar conditions in similar circumstances to other undertakings...". Consequently, the network operator does not necessarily have to offer identical contracts to a competing firm and a complementary firm. In the present paper we focus on how the input monopolist should set input prices to maximise its profits, and allow complete pricing flexibility to the vertically integrated firm subject only to informational constraints.¹

This paper deals with input price discrimination when the downstream markets

¹The issue of non-discrimination is discussed in Sand (2004b) in the context of full information.

are interrelated. The input monopolist may sell to both downstream rivals and to firms in adjacent markets that may be more or less related. The issue of input price discrimination is discussed by, among others, Schmalensee (1981), Katz (1987), DeGraba (1990), Yoshida (2000), and Valetti (2003).² In dealing with price discrimination in the final product market, Varian (1985) establishes that a necessary condition for price discrimination to improve welfare is that output increases. Both Yoshida (2000) and Valetti (2003) obtain different results when analysing input price discrimination, and show that in some cases welfare only increases when the final output falls. Valetti (2003) furthermore shows that input price discrimination can be detrimental both in terms of a lower consumers' surplus and lower total welfare even if the upstream monopolist has no incentive to favour a particular downstream firm. Panzar and Sibley (1989) consider the determination of optimal two-part tariffs for inputs by a regulator. The present paper extends the analysis of input price discrimination to allow for multiple (and possibly related) downstream markets.³ Furthermore, in the present model the upstream monopolist in the present model has only imperfect knowledge about the demand for the final products in the downstream markets. This paper attempts to investigate how such an upstream monopolist should set its prices in the presence of both asymmetric information about market sizes and an adjacent market that may be either a substitute or complement to the competitive market segment.

The rest of the paper is organised as follows: In section 2, the model is presented and the analysis of the upstream monopolist's pricing decision under both full and asymmetric information is undertaken. In section 3 some concluding remarks are made.

²Armstrong and Vickers (1991) discuss the desirability of price discrimination when faced with a multiproduct monopolist who is subject to a price-cap regulation. In Armstrong and Vickers (1993) the issue of price discrimination and entry is discussed.

³In Yoshida (2000) and Valetti (2003) there is only one downstream market, with homogenous goods and firms that compete in a Cournot fashion.

2 The model

In the present model there are two types of firms; the upstream market - distributors (e.g., digital distribution networks) and the downstream market - content providers. These firms operate in vertically related markets, and the distribution network is an essential input in the production of content. For simplicity, I consider a setting with only one distribution network (firm U). In the content market, there are three firms (firms D_1 , D_2 and D_a). Firms U and D_1 are assumed to be vertically integrated (denoted VIF), whereas firms D_2 and D_a are independent content providers. Firms D_1 and D_2 produce products that may be vertically differentiated but otherwise identical, whereas firm D_a is active in an adjacent market that may be related to the market that D_1 and D_2 competes in.⁴ It is assumed that the downstream firms compete á la Cournot, and the pricing of the independent downstream firms cannot be included in the contract between the upstream and downstream firms.

The game is played in two stages. In the first stage of the game, the distribution network decides on a set of access charges. In the second stage, the downstream firms compete in quantities.

The distributor's profit is given as:

$$\pi_u = t_1 + t_2 + t_a - F \quad (1)$$

where t_i is the access charge paid by the content providers for the use of the digital distribution network. In general, the access charge will be a function $t_i(q_i)$ that may be non-linear, in which case we may implement the access charge through a menu of linear tariffs. The access charge may also be a linear tariff, with $t_i = w_i q_i$, where w_i is the unit fee charged for access. The tariff may also be a simple two-part tariff with $t_i = A_i + w_i q_i$, where A_i is a fixed component of the access charge. The parameter F is a fixed cost. Each of the content providers supplies an amount q_i of the final product.

The content providers' profit, where $i = 1, 2$, is given as:

$$\pi_i = P_i q_i - t_i \quad (2)$$

⁴Competition in adjacent markets is discussed in detail in Rey, Seabright and Tirole (2001).

and for the adjacent market:

$$\pi_a = P_a q_a - t_a \quad (3)$$

The inverse demand function in the competitive market is given by:

$$P_i = \theta_i - q_1 - q_2 - \sigma q_a \quad (4)$$

and in the adjacent market

$$P_a = \alpha - q_a - \sigma (q_1 + q_2) \quad (5)$$

It is assumed that the final product is sold at a uniform price, P_1 , P_2 and P_a , with no price discrimination within each sub-market. The parameter σ is a measure of how related the adjacent and competitive markets are, with $-1 < \sigma < 1$. For $\sigma < 0$, the markets produce complementary products, while for $\sigma > 0$ the markets produce substitute products. The parameters θ_i , for $i = 1, 2$, and α measures the size of the markets in the competitive and adjacent market segments. Allowing for differences in θ_1 and θ_2 may be interpreted as perceived quality differences between firms D_1 and D_2 . The size of the markets involved may not be common knowledge. The adjacent market can be seen as an emerging market, and the size of this market may not be known by the parties involved. It can also be argued that size of the competitive market may fluctuate, and that the true market size for a given sub-market is only perfectly observed by the individual firm.

Let the size of the market for the downstream subsidiary of the network operator be common knowledge. Consequently, we will assume that only θ_2 and α are random variables.⁵ We will for simplicity assume that all firms observe perfectly the degree of relatedness between the competitive and adjacent markets; i.e., σ is common knowledge. Let us assume that the market size of the two firms, D_2 and D_a , in the competitive and adjacent markets are perceived to be (independently) distributed according to common knowledge distributions. Let the (cumulative) distribution function for firm D_2 be given as $F(\theta_2)$, with corresponding density function, which

⁵The random variables may also be interpreted as a measure of product quality, and hence of vertical differentiation.

is assumed to be strictly positive over the relevant range $\theta_2 \in [\underline{\theta}, \bar{\theta}]$.⁶ Furthermore, $F(\underline{\theta}) = 0$ and $F(\bar{\theta}) = 1$. For the adjacent market, let the market size α be distributed according to the (cumulative) distribution function $G(\alpha)$, with corresponding density function, which is strictly positive over the relevant range $\alpha \in [\underline{\alpha}, \bar{\alpha}]$. Furthermore, $G(\underline{\alpha}) = 0$ and $G(\bar{\alpha}) = 1$.

2.1 Equilibrium

2.1.1 Final stage equilibrium

Firms U and D_1 act as a vertically integrated firm (VIF), and the VIF will maximise $\pi_v(\theta_1, \theta_2, \alpha)$, where expectations are taken over α and θ_2 . Let $\pi_v(\theta_1, \theta_2, \alpha) \equiv E_\alpha [E_\theta [\pi_u(\alpha, \theta_2) + \pi_1(\alpha, \theta_2)]]$.⁷ Firm D_2 maximises expected profit, $\pi_2(\theta_2) \equiv E_\alpha [\pi_2(\alpha, \theta_2)]$, with respect to q_2 . The firm in the adjacent market, D_a , maximises expected profit, $\pi_a(\alpha) \equiv E_\theta [\pi_a(\alpha, \theta_2)]$, with respect to q_a .

2.1.2 Access charge determination: The case of no regulation

Full information If the upstream firm has full information about all relevant parameters and is not subjected to any restrictions on the structure or level of prices, the contracts may be designed to extract the entire industry profit. Firm D_2 produces a product that may be vertically differentiated relative to the product provided by the VIF's own subsidiary. If D_2 provides a product of inferior (intrinsic) value, $\theta_2 \leq \theta_1$, the VIF will set a contract (w_2, t_2) such that D_2 chooses not to be active. If, on the other hand, $\theta_2 > \theta_1$, then the VIF will offer a contract that induces D_2 to produce in its segment of the competitive market, but choose not to let D_1 be active. Since it is only the market size parameter (or willingness to pay parameter)

⁶Note, however, that the relevant lower bound on the distribution of θ_2 should strictly speaking be θ_1 , since the VIF will never choose to let D_2 produce in equilibrium if D_2 produces an inferior product. However, for now the lower bound is stated as $\underline{\theta}$. This will be discussed in more detail below.

⁷Let $E_\theta [x] \equiv \int_{\underline{\theta}}^{\bar{\theta}} x f(\theta) d\theta$.

that differs between the products of D_1 and D_2 , the *VIF* will naturally not choose to let both firms supply the output if free to choose the appropriate contract.

For D_a the contract (w_a, t_a) that maximises the *VIF*'s profit will, if the markets are unrelated, be such that D_a produces its monopoly output and the monopoly profit is captured by *VIF* through the fixed fee. By making D_a the residual claimant he will have incentives to choose the monopoly output if facing the true upstream marginal cost. The downstream (monopoly) profit is captured through the fixed fee. This implies $w_a = 0$ and $t_a = (q_a^m)^2$, where q_a^m is D_a 's monopoly output. This yields $\pi_a = 0$. If $\sigma > 0$, the two downstream markets produce substitute products and there will be profit shifting between the two downstream markets. Provided that the products are less than perfect substitutes, the *VIF* will gain from inducing D_a to produce a positive level of output since D_a will provide additional value. As long as the *VIF* is free to set (two-part) access charges, the *VIF* can capture the entire surplus of D_a through the fixed fee which is set such that $\pi_a(w_a, t_a) \geq 0$.

The *VIF* behaves as if he maximises the joint profit of D_1 , D_2 and D_a to maximise total (potential) surplus, in which case we obtain the following equilibrium quantities:

Proposition 1 *Provided that $\sigma\theta_i < \alpha < \theta_i/\sigma$, for $i = 1, 2$, the equilibrium outputs for D_1 , D_2 and D_a are given by (for $i, j = 1, 2, i \neq j$):*

$$q_i^* = \begin{cases} \frac{\theta_i - \sigma\alpha}{2(1 - \sigma^2)} & \text{if } \theta_i \geq \theta_j \\ 0 & \text{if } \theta_i < \theta_j \end{cases} \quad (6)$$

$$q_a^* = \begin{cases} \frac{\alpha - \sigma\theta_1}{2(1 - \sigma^2)} & \text{if } \theta_1 \geq \theta_2 \\ \frac{\alpha - \sigma\theta_2}{2(1 - \sigma^2)} & \text{if } \theta_1 < \theta_2 \end{cases} \quad (7)$$

The output in the competitive market segment, q_i^* , induced by the network operator, is provided by either D_1 if $\theta_2 \leq \theta_1$, or by D_2 if $\theta_2 > \theta_1$. Hence, efficiency is ensured. We observe that if $\sigma = 0$, the outputs are indeed their respective monopoly outputs. The monopoly surplus is captured through an appropriate determination of the fixed fee. Under full information with no restrictions on the contracts between

the network operator and independent access seekers, we obtain first-best efficiency with marginal cost pricing of usage and a fixed component to cover fixed costs and capture the industry profit.

Corollary *To implement the outputs corresponding to Proposition 1 and that the entire industry profit is captured, the network provider offers the following (take-it-or-leave-it) access tariffs (where $\varepsilon > 0$):*

$$t_i(q_i) = \begin{cases} (q_i^*)^2 & \text{when } \theta_i \geq \theta_j, \text{ if } q_i = q_i^* \\ (q_i)^2 + \varepsilon & \text{otherwise} \end{cases}$$

$$t_a(q_a) = \begin{cases} (q_a^*)^2, & \text{if } q_a = q_a^* \\ (q_a)^2 + \varepsilon & \text{otherwise} \end{cases}$$

For outputs (6) and (7) to be an equilibrium, we require that $\sigma\alpha < \theta_i$ and $\alpha > \sigma\theta_i$, for $i = 1, 2$. This is obviously satisfied for $\sigma \leq 0$, but not necessarily for $\sigma > 0$. If the set of parameter values $(\alpha, \theta_1, \theta_2)$ is such that $\sigma\alpha > \max\{\theta_1, \theta_2\}$, then we observe from (6) that $q_i^* < 0$ which implies that only the adjacent market is served. This could happen if the adjacent and the competitive markets are sufficiently close substitutes and the competitive market is small relative to the adjacent market. If both markets are served and the markets are sufficiently close substitutes, an increase in output in either market will have a significant impact on the price obtained in downstream markets. The less substitutable the products are, the smaller is this effect on prices. Consequently, by essentially shutting down the competitive market the vertically integrated firm is able to better exploit its monopoly power. If $\alpha < \sigma\theta_i$, for $i = 1, 2$, then D_a becomes inactive. In this case, the value (or quality) of D_a 's product is too low relative to σ and θ_i . If the products are sufficiently close substitutes (i.e., σ close enough to 1) an expansion in output by either firm will have (close to) the same marginal effect on willingness to pay. Consequently, if the value from selling an extra unit in the adjacent market is low (that will be the case when α is low), this marginal gain will not outweigh the loss on inframarginal units in the competitive market. If $\sigma = 1$, the relative magnitude of α , θ_1 and θ_2 will

determine which firm is active. As is standard in a monopoly, the upstream firm can only induce higher level of sales downstream (i.e., the increase in output in the adjacent market) by reducing the price to all (inframarginal) consumers.

Asymmetric information Under asymmetric information, it is reasonable to expect that a first-best solution cannot be realised even if there are no restrictions on the contracts between the network operator and access seekers.⁸ If the network operator can only observe the market size imperfectly, the *VIF* must ensure that contracts are incentive compatible and meet the participation constraints of the firms. From the revelation principle (Myerson, 1979) we know that the the principal (the *VIF* in this case) can restrict his attention to a direct revelation contract; $M_k = \left\{ q_k(\hat{\alpha}, \hat{\theta}_2), t_k(\hat{\alpha}, \hat{\theta}_2) \right\}$, for $k = 2, a$, where $\hat{\alpha}$ and $\hat{\theta}_2$ denote the reports (of type) to the *VIF*. In order for the *VIF* to maximise profits under asymmetric information, the following conditions must be met:⁹

$$(IC_2) \quad E_\alpha [\pi_2(\alpha, \theta_2)] \geq E_\alpha [\pi_2(\alpha, \hat{\theta}_2)], \quad \forall (\theta_2, \hat{\theta}_2)$$

$$(IC_a) \quad E_\theta [\pi_a(\alpha, \theta_2)] \geq E_\theta [\pi_a(\hat{\alpha}, \theta_2)], \quad \forall (\alpha, \hat{\alpha})$$

and

$$(PC_2) \quad E_\alpha [\pi_2(\alpha, \theta_2)] \geq 0, \quad \forall \theta_2$$

$$(PC_a) \quad E_\theta [\pi_a(\alpha, \theta_2)] \geq 0, \quad \forall \alpha$$

Local incentive compatibility requires the following (using the envelope theorem):¹⁰

$$\frac{d\pi_2(\theta_2)}{d\theta_2} = \frac{\partial \pi_2(\theta_2)}{\partial \theta_2} + \frac{\partial \pi_2(\theta_2)}{\partial q_a} \frac{\partial q_a}{\partial \theta_2} = E_\alpha [q_2(\alpha, \theta_2)] \left(1 - \sigma \frac{\partial q_a}{\partial \theta_2} \right) \geq 0 \quad (8)$$

⁸In their seminal article, Lewis and Sappington (1988) show that with unknown demand the first-best can be implemented. In the current setting, with imperfect competition and unknown demand, this is no longer the case.

⁹A more detailed analysis of incentive compatible mechanisms can be found in Guesnerie and Laffont (1984).

¹⁰By the envelope theorem, and since D_2 is only active if D_1 is not, we have: $\frac{d\pi_2(\theta_2)}{d\theta_2} = \frac{\partial \pi_2(\theta_2)}{\partial \theta_2} + \frac{\partial \pi_2(\theta_2)}{\partial q_a} \frac{\partial q_a}{\partial \theta_2}$ and $\frac{d\pi_a(\alpha)}{d\alpha} = \frac{\partial \pi_a(\alpha)}{\partial \alpha} + \frac{\partial \pi_a(\alpha)}{\partial q_i} \frac{\partial q_i}{\partial \alpha}$, for $i = 1, 2$.

$$\frac{d\pi_a(\alpha)}{d\alpha} = \frac{\partial\pi_a(\alpha)}{\partial\alpha} + \frac{\partial\pi_a(\alpha)}{\partial q_i} \frac{\partial q_i}{\partial\alpha} = E_\theta [q_a(\alpha, \theta_2)] \left(1 - \sigma \frac{\partial q_i}{\partial\alpha}\right) \geq 0 \quad (9)$$

The local incentive compatibility constraint for D_2 and D_a correspond to the standard monopoly models for $\sigma = 0$, and there is no strategic interaction term between firms D_1 and D_2 since only one of these firms will be active.

Both firms will earn information rents, provided that they both are active in equilibrium, except for types $\underline{\alpha}$ and $\underline{\theta}$. The information rent of the two firms may be written as:

$$\pi_2^*(\theta_2) = \int_{\underline{\theta}}^{\theta_2} \left(E_\alpha [q_2(\alpha, \theta_2)] \left(1 - \sigma \frac{\partial q_a}{\partial\theta_2}\right) \right) dF(\theta_2) \quad (10)$$

$$\pi_a^*(\alpha) = \int_{\underline{\alpha}}^{\alpha} \left(E_\theta [q_a(\alpha, \theta_2)] \left(1 - \sigma \frac{\partial q_i}{\partial\alpha}\right) \right) dG(\alpha) \quad (11)$$

To ensure that the information rent is positive, the expressions $\left(1 - \sigma \frac{\partial q_a}{\partial\theta_2}\right)$ and $\left(1 - \sigma \frac{\partial q_i}{\partial\alpha}\right)$ must be non-negative.

Assumption 1 *Sufficient conditions for non-negative information rents: i) If $\sigma > 0$ (substitutes), then $\frac{\partial q_a}{\partial\theta_2} \leq 0$ and $\frac{\partial q_i}{\partial\alpha} \leq 0$, and ii) If $\sigma < 0$ (complements), then $\frac{\partial q_a}{\partial\theta_2} \geq 0$ and $\frac{\partial q_i}{\partial\alpha} \geq 0$.¹¹*

We observe that the information rent is decreasing in σ when $\sigma > 0$, all other things being equal, and increasing in σ for $\sigma < 0$. This implies that it is more costly to induce truthful revelation when the competitive and adjacent markets are strong complements. A change in the output of one of, say, the firms in the competitive market will have a direct impact on the information rent in that particular market. In addition, there will be an indirect impact on the information rent in the adjacent market and the information rents in the two markets are interdependent through the effect on equilibrium outputs.

¹¹Consequently, if the products are substitutes, an increase in the competitive market size results in a reduction in output in the adjacent market (and that an increase in the size of the adjacent market results in a reduction in output in the competitive market). This is reasonable, since an increase in the size of the market normally results in an increase in output for that particular market. A similar story goes for the case of complements.

The *VIF* will face the following maximisation problem under asymmetric information (after inserting for transfers and simplifying):

$$\begin{aligned} & \max_{\{q_1, q_2, q_a\}} E_\theta E_\alpha [\pi_v(\alpha, \theta_1, \theta_2)] \\ &= \int_\alpha \int_{\theta_2} (P_1 q_1 + P_2 q_2 + P_a q_a - \pi_2^*(\theta_2) - \pi_a^*(\alpha)) dF(\theta_2) dG(\alpha) \end{aligned}$$

where $\pi_2^*(\theta_2)$ is defined by (10) and $\pi_a^*(\alpha)$ is defined by (11). Inserting for the information rents, and integrating by parts the incentive constraints we obtain the *VIF*'s virtual surplus:

$$\begin{aligned} E_{\alpha, \theta} [VS] &= \int_{\underline{\alpha}}^{\bar{\alpha}} \int_{\underline{\theta}}^{\bar{\theta}} \left(P_1 q_1 + P_2 q_2 + P_a q_a - \frac{1 - F(\theta_2)}{f(\theta_2)} q_2 \left(1 - \sigma \frac{\partial q_a}{\partial \theta_2} \right) \right. \\ &\quad \left. - \frac{1 - G(\alpha)}{g(\alpha)} q_a \left(1 - \sigma \frac{\partial q_i}{\partial \alpha} \right) \right) dF(\theta_2) dG(\alpha) \end{aligned} \quad (12)$$

Maximising (12) with respect to $\{q_1, q_2, q_a\}$ defines q_1^{*AI} , q_2^{*AI} and q_a^{*AI} , and is given by the following:

Proposition 2 *Assuming that the upstream firm has only imperfect information about the demand for D_2 's and D_a 's products, the following are the equilibrium outputs q_1^{*AI} , q_2^{*AI} and q_a^{*AI} :*

$$E_\alpha E_\theta [P_1 - q_1 - \sigma q_a] = 0, \quad \text{if } \theta_2 \leq \tilde{\theta} \quad (13)$$

$$E_\alpha [P_2 - q_2 - \sigma q_a] = E_\alpha \left[\frac{1 - F(\theta_2)}{f(\theta_2)} \left(1 - \sigma \frac{\partial q_a}{\partial \theta_2} \right) \right], \quad \text{if } \theta_2 > \tilde{\theta} \quad (14)$$

$$E_\theta [P_a - q_a - \sigma q_i] = E_\theta \left[\frac{1 - G(\alpha)}{g(\alpha)} \left(1 - \sigma \frac{\partial q_i}{\partial \alpha} \right) \right], \quad i = 1, 2 \quad (15)$$

We observe that if the *VIF* chooses to let D_1 supply the competitive market, the outcome is equivalent to the first-best solution obtained under full information since there is no asymmetric information between the *VIF* and D_1 . If the *VIF* chooses to let D_2 supply the competitive market, then the quantity under asymmetric information is lower than under full information. The same applies to the adjacent market. This is a familiar result in models with asymmetric information, and is

due to the *VIF*'s trade-off between efficiency and rent extraction. A lower output reduces the information rent necessary to induce truthful revelation, but comes at the expense of the *VIF*'s ability to capture the entire industry profit.

Corollary *i) The output of firm D_1 , if chosen to supply the market, is equivalent to the full information case ($q_1^{*FI} = q_1^{*AI}$). The output of D_2 and D_a will be distorted downwards relative to the full information solution ($q_2^{*FI} \geq q_2^{*AI}$ and $q_a^{*FI} \geq q_a^{*AI}$).*

ii) There is an additional inefficiency caused by D_1 being selected to supply the market even when D_2 produces a superior product.

Part (ii) of the corollary deserves closer attention. When comparing the asymmetric information outcome to the full information case there is an additional inefficiency due to the fact that the supply decision in the competitive market also may be distorted. By supply decision we understand that this is the choice about which of the two firms in the competitive market should supply the market. In the full information case the firm with the highest quality product, be it D_1 or D_2 , is chosen to supply the market, since there are no cost asymmetries. In the case of asymmetric information, the cost of producing for D_1 and D_2 is different due to the information rent that is necessary to induce truthful revelation by D_2 . It is therefore reasonable to suspect that D_1 will supply the competitive market even if $\theta_1 < \theta_2$.

For $\theta_1 \geq \theta_2$ the *VIF* will always choose to let firm D_1 to supply the competitive market alone. Let us define $\tilde{\theta}_2$, such that the *VIF* will choose D_2 to produce only if $\theta_1 \leq \tilde{\theta}_2$. Maximising $E_{\alpha,\theta}[VS]$, with respect to the lower bound on the distribution $\tilde{\theta}$ yields the following trade-off:

$$E_{\alpha} \left[P_2(\tilde{\theta}_2) - q_2(\tilde{\theta}_2) - \sigma q_a(\tilde{\theta}_2) \right] f(\tilde{\theta}_2) = E_{\alpha} \left[\left(1 - F(\tilde{\theta}_2) \right) \left(1 - \sigma \frac{\partial q_a(\tilde{\theta}_2)}{\partial \theta_2} \right) \right] \quad (16)$$

The left-hand side of eqn.(16) is the marginal profitability of serving firm D_2 of type $\tilde{\theta}_2$, whereas the right-hand side is the information rent associated with serving firm D_2 of types $[\tilde{\theta}_2, \bar{\theta}]$; i.e., the additional information rent awarded to types with higher intrinsic product value than $\tilde{\theta}_2$. Since the information rent on the right-hand side is assumed to be positive, the added cost associated with inducing D_2

to produce will create an asymmetry between firms D_1 and D_2 . This asymmetry causes, all other things equal, the cut-off level $\tilde{\theta}_2$ to be higher than θ_2 . The cut-off level will be influenced by, among other things, the sign and level of σ . As is standard in models of monopoly regulation, the output of firm D_2 is not (at least initially) affected by the cut-off point $\tilde{\theta}_2$.¹² However, in the present model the output of firm D_a may be affected, since a truncation of the support of θ_2 affects the expectations of the firm in the adjacent market.

Without any truncation of θ_2 , the output of firm D_2 will be determined by the following relationship:

$$\int_{\underline{\theta}}^{\bar{\theta}} \left[P_a - q_a - \sigma q_i - \frac{1 - G(\alpha)}{g(\alpha)} \left(1 - \sigma \frac{\partial q_i}{\partial \alpha} \right) \right] f(\theta_2) d\theta_2 = 0 \quad (17)$$

When the support of θ_2 is truncated at θ_2^* , the following relationship determines the output of D_a :

$$\int_{\theta_2^*}^{\bar{\theta}} \left[P_a - q_a - \sigma q_i - \frac{1 - G(\alpha)}{g(\alpha)} \left(1 - \sigma \frac{\partial q_i}{\partial \alpha} \right) \right] f(\theta_2) d\theta_2 = 0 \quad (18)$$

Differentiating eqn. (18) with respect to θ_2^* , we find the following:

$$- \left(P_a - q_a - \sigma q_i - \frac{1 - G(\alpha)}{g(\alpha)} \left(1 - \sigma \frac{\partial q_i}{\partial \alpha} \right) \right) < 0$$

This expression is negative if we assume an interior solution for q_a^{**AI} . Consequently, q_a is distorted upwards from q_a^{*AI} . Let this level of output be denoted q_a^{**AI} . Since the competitive and adjacent market segments are related (when $\sigma \neq 0$) the distortion in q_a will eventually have an impact on the output in the competitive market. How the competitive market is affected will depend on the sign of σ . If $\sigma < 0$, the products in the two markets are complements and increasing the output of firm D_a this will increase the output of either D_1 or D_2 , depending on which firm is active. If $\sigma > 0$, the increase in q_a from the truncation of θ_2 leads to a reduction in the competitive market output.

¹²See Laffont & Tirole (1993: Ch. ?).

Since the truncation of θ_2 affects output, this will impact on the information rents to the independent firms. When q_a increases, the information rent to D_a inevitably increases. For firm D_2 the information rent will increase if markets are complements, and will decrease if markets are substitutes:

Proposition 3 *Assume that $\theta_2 \geq \tilde{\theta}_2$ for a given truncation point $\tilde{\theta}_2$:*

i) If the adjacent and competitive markets produce complementary outputs, the information rent necessary to induce truthful revelation by firm D_2 increases with an upward truncation of θ_2 .

ii) If the adjacent and competitive markets produce substitute outputs, the information rent necessary to induce truthful revelation by firm D_2 decreases with an upward truncation of θ_2 .

The cross-effect that the truncation point has on firm D_a 's output and consequently on the competitive output and information rents, will naturally influence on the optimal truncation point and may make the interval in which the own downstream subsidiary is the preferred supplier either larger or smaller depending on how the downstream markets are related:

Corollary

i) When markets are complementary, the information rent to firm D_2 is higher than in the absence of market interdependence. Firm D_1 will then be the preferred supplier for a larger interval for θ_1 .

ii) When markets are substitutes, the information rent to firm D_2 is lower than in the absence of market interdependence. Firm D_1 will then be the preferred supplier for a smaller interval for θ_1 .

Since the upstream monopolist is only imperfectly informed about the state of demand facing in particular D_2 (but also D_a) in the downstream sub-markets, implies that outsourcing production in the competitive market segment to the independent firm D_2 becomes more costly due to the information rent. If the quality differentiation effect becomes sufficiently pronounced this may compensate for the

information cost. Consequently, the asymmetry of information results in a truncation of the support for θ_2 . Truncating the support has no direct effect on output in the competitive market, but it implies as we have seen that the output of the firm in the adjacent market increases and an indirect effect on the competitive output. When the competitive and adjacent markets produce complementary products, an increase in q_a is followed by an increase in q_2 .¹³ The increase in output for firm D_2 results in higher information rents to D_2 , which adds to the cost of outsourcing downstream production. This implies that the interval for θ_2 in which outsourcing is desirable for the upstream monopolist becomes smaller. The opposite is true when the adjacent and competitive markets produce substitute products. Then an increase in q_a following the truncation in the support for θ_2 results in a contraction in output in the competitive market segment, and consequently a reduction in the information rent. This makes it less costly to outsource the production in the competitive market segment to firm D_2 .

3 Concluding remarks

The present paper has examined the issue of input price discrimination in the context of multiple and possibly related downstream markets, and the analysis of the monopolist's choice pricing is extended to allow for asymmetry of information about demand in the downstream markets. This asymmetry of information creates, in addition to the standard inefficiencies, a selection inefficiency due to the fact that this introduces asymmetry in the cost of the downstream production. The downstream subsidiary of the network provider will reveal the information about its own downstream demand at no extra cost, whereas the downstream rival in the competitive market segment must be awarded an information rent. This causes the upstream firm to prefer contracting with its own downstream subsidiary even when the rival produces a superior product (and the rival would be chosen as the preferred provider

¹³This is provided that D_2 is active. If D_2 is not active, or equivalently that θ_2 is not sufficiently high, then the resulting increase in q_1 when q_a increases has no consequence for the chosen level of truncation.

under full information), which again results in a truncation in the distribution of the rival's demand and consequently an effect on the output by the rival and the information rent. Since the output of one firm in the competitive market segment impacts on the optimal output of the other firm, the truncation has an indirect impact on the network provider's downstream subsidiary.

It has been assumed throughout that the level of the access charge is not subject to regulation. A potential extension to the present paper would be to examine the socially optimal set of prices, but this is beyond the scope of this paper. Furthermore, non-discrimination requirements in regulatory policy are important aspects that warrant closer examination in the setting of asymmetric (downstream) competitors. Some degree of flexibility may be beneficial to cater for the asymmetries, but this may come at the expense of the VIF choosing not to award access to some firms. In addition, the information structure is such that the upstream firm knows the degree to which the competitive market segment and the adjacent market is related, but does not know the market sizes. This may be a reasonable assumption if, for instance, we investigate to fairly mature markets where the link between the markets have been established. Market demand may, however, still fluctuate due to exogenous factors. An example of this could be that we by now observe that mobile and fixed line telephones are fairly close substitutes for a number of subscribers, a development that might not have been expected when the mobile phone was introduced.

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