Content Delivery and Vertical Integration in O-L Content Markets

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Abstract. On-line content delivery and vertical alliances between conduit and content providers are nowadays crucial issues in digital markets. In this paper, we discuss and compare a *push* and a *pull* model for on-line content delivery in the case of non-zero marginal cost for network transits because of *network services for content delivery* (like data caching). Under both models, we show that rationales for vertical strategic integration between conduit and content providers phase out in successive monopolies and Bertrand duopolies.

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1. Introduction

On-line content delivery (henceforth simply *CD*) is receiving increasing attention by commentators, scholars and advisers especially after the Napster dispute. Almost unanimously, Internet Service Providers' managers and researchers agree on the fact that new multimedia applications (like movies or news on demand, video conferencing, multiplayer interactive games or other high added value services) will be one of the most important sources of profits for providers of information products in the next-generation-Internet[1]. Moreover, recent mergers between Internet Service providers (Network Providers- *NP*, henceforth), large cable companies and content providers (Content Provider-*CP*, henceforth) or data aggregators (portals)[2] have posed several challenging questions to economic theory.

First of all, under which conditions a vertical integration between a conduit provider and a content one turns out to be an optimal strategy ?

Secondly, what kind of technological improvements in performing content delivery may be achieved via vertical integration ?

Finally, is vertical integration between providers a profit maximizing strategy independently from the architecture of information systems for what concerns on-line content delivery ?

In what follows, we present a simple microeconomic model where price decisions of content and conduit providers are analyzed.

First of all, we suppose a CP supplying non-sustitutable content at negligible marginal costs and totally paid-off upfront costs (i.e. exclusive U2's videos or MP3s) and a NP which owns an *essential network loop* without which it is impossible to reach some CCs. The network firm provides *network services* for CD (like caching, dynamic distillation, media scaling etc...) at a constant marginal cost. These costs are paid by both CPs and CCs at a given constant proportion.

Following computer scientists' insights, we discuss two models of content delivery: a *Pull Model*, in which contents are pulled by CCs and a *Push* one where multimedia streams are pushed into the web by a provider. It is showed that vertical integration is a profit maximizing decision for both providers, except when contents are pulled and network services' costs are heavily translated on CCs. Moreover, in a Bertrand competition model where duopolies compete in homogeneous network services and contents, we show that vertical integration is a profit enhancing strategy if and only if it generates some *asymmetries* in network functionalities between integrated and non-integrated firms. We will discuss that these asymmetries are due to better performed *active networking services* (see below for details).

[1] For a well-grounded discussion of the so-called "Napsterization" of the content industry see Rapp (2000). A first attempt to map web content demand may be found in Paltridge (1999).

[2] For instance, recent mergers between AOL and Time Warner, AT&T and MediaOne or MCI, WorldCom and Sprint.

The paper is organized as follows. In the next section we review and discuss the existing literature on CD. In section 3 we present the main model setup and we discuss some rationales for vertical integration between monopolistic providers. In Section 4, we study Bertrand duopolistic competition between symmetric firms. Section 5 concludes.

2. Related Literature

Despite the large debate among practitioners in the press, digital content delivery has not been deeply investigated neither among economists nor among computer scientists.

On the computer science's side, researchers are used to model network architectures which maximize added value of on-line content delivery value chains. Among these, Liver and Dermler (2000) point the crucial role played by the content delivery quality of service (*CdQoS*, henceforth) in the interaction between content and conduit providers. However, CdQoS is not normally guaranteed on an end-to-end basis by the conduit provider and it cannot be easily controlled by who provide on-line contents. Hence, according to Liver and Dermler (2000) they conclude, a content delivery value-chain model should include some *Service Level Agreement (* SLA*)* between content providers and network providers. Such a SLA has to specify CdQoS and its relative price at any time of the day.

In a similar vein, Rousseau and Duda (2000) and Harumoto et al. (2000) suggest some technical functionalities that an information system[3] should have in order to deal with content delivery and ensuring a sufficiently stable quality of service.

As we will discuss later, these studies raise interesting issues traditionally unexplored by economists. In particular, for example, the role of active networking services is recognized as crucial to reduce network latency and risks of breakdowns.

On the economics' side, a visible delay in analyzing the topic of on-line content delivery has be recently recognized by Rubinfeld and Singer (2001)[4]. As in the case represented by the merger between America On Line and Time Warner, economists do not have a model to analyzing anticompetitive effects of vertical integrations between content providers and conduit operators. In principle an *IP* might implement at least two kind of discriminatory behaviors: (i) a *content discrimination* (i.e. do not accept rivals' contents on my conduit) or (ii) a *conduit discrimination* (i.e. do not allow my content to be delivered by an alternative network provider). Under some conditions, both practices are profitable for an IP and harmful for de-integrated competitors[5].

Nevertheless, Rubinfeld and Singer (2001) assume *vertical integration* between providers without any formal analysis about its optimality. On the other hand, on this issue Jungsuk and Chang (2000) try to justify better vertical integration by using a two stage game

[3] They define an information system as the union of a content server, a network infrastructure and a client browser.

[4] A model of vertical integration between an information products producer and an offline dealer can be found in Waterman (1993).

[5] Among others, Salinger (1988) and Abiru (1988) shown similar results for off-line markets. Traditional additional references on vertical integration are: Hart and Tirole (1990) and Ordover et al. (1990). Mattoo (2001) considers a multi-stage oligopolistic model where decisions to merge are treated as endogenous.

between two oligopolistic firms: a NP and a CP. However, they focus on a very specific form of vertical integration (traditionally intended as a unique ownership and common strategic management), which is a common practice in digital markets: *price bundling* between NPs' and CPs' services. In the first stage of the game by Jungsuk and Chang (2000), providers choose simultaneously product quality then they compete in prices. Defining CdQoS in terms of dowload waiting time and assuming zero marginal costs for both providers, they determine which effects has second-stage price bundling on aggregate profits and services' quality. Jungsuk and Chang (2000) show that a *strategic vertical alliances* generally increases both aggregate profits and services' quality.

Some further observations on Jungsuk and Chang's paper may introduce to our aims. They model price competition among content and conduit providers as occuring on the same market, not on two separate market structures for network and contents services. Therefore, this setup is unlikely able to deal with successive monopolies or with digital markets where *horizontal price competition* between CPs or Nps takes place. In case of successive monopolies, *vertical price externalities* become a crucial issue[6], while in horizontal competition paradigms *price undercutting* tactics turn out to play a major role. The analysis of Jungsuk and Chang (2000) lacks of any reference to both possibilities. Moreover, the multi-stage/simultaneous competitive game proposed by Jungsuk and Chang (2000) is not the appropriate game form since network applications for content delivery have usually a sequential structure (see Liver and Dermler (2000)) and price decisions are consistently assumed sequentially. This is especially true, when both providers are monopolists and they can impose *take-it-or-leave-it* choices to the other player. In such cases, first moving advantages play a crucial role in aggregate profit partition. Finally, if active network services are essential in defining CdQoS, some positive marginal costs emerge. Therefore, it is rather misleading to assume CdQoS simply declined as waiting time and zero marginal transit costs.

Furthermore, economic modeling neglects the existence of two alternative architectures for CD (see below for details). Some applications require contents to be pushed by the CP (like video-conferencing, Internet Radio or WebTV), while other contents (MP3, DivX, e-books) can be pulled by consumers. Thus, we missed a clear answer to a spountaneous question: is profitability of vertical integration between network firms and content providers invariant with respect to different network architectures for content delivery ? In order to explore these issues, in the following pages we develop a simple microeconomic model.

3. Networks Architectures for CD and The Successive Monopolies Case

On-line contents, as stressed, may be delivered using either a *Pull* or a *Push* model (see Liver and Dermler (2000)). In the former, data transfers are initiated by CCs which select and retrieve some information products. In the latter, the CP provider offers on-

[6] Spengler (1950) is the seminal contribution on the so called "double marginalization effect".

line digital contents to some identified CCs which may or not accept the offer. Let us illustrates how both models work for successive monopolies and how these can be modeled.

- **The Pull Model of CD:** some CCs want to buy a single unit of a content from a CP (for instance a video-interview to Bono Vox exclusively released on the web by U2.COM). CCs send a request to their network provider by using their web browsers. The NP who manages monopolistically a network loop without which the CP cannot deliver its product, once received a request the NP does re-direct it to the CP together with a *price for network services* (t) required for that data format. Then, the content provider decides whether or not satisfy the consumers' demand. In the affirmative case, CP replies to the NP's server a *content price* (p). Finally, prices are sent to CCs who may decide whether to buy or not.

- **The Push Model of CD:** in this case the CP decides at first contents' prices (p) then it sends proposals to CCs through a network loop managed by a NP. The latter directs proposals to its subscribers, selling network services to the CP at a price (t). Once CCs have decided to buy the content, their replies are then re-directed to CP.

For both models, we suppose to have N CCs forming the demand side. Each consumer buys only one unit of content. Preferences are represented by the following utility function:

$$u = \delta s_0 - p - \alpha t$$

δ is a preference parameter for quality, uniformly distributed on a unit support; s_0 is the content quality (dependent on network services' quality implemented by the NP); p is the content price and αt with $\alpha \in [0;1]$ indicates his/her exogeneously fixed share of network services' costs. Traditionally, if $u < 0$ then CCs do not buy. Hence, other things equal, the content is purchased by those consumers characterized by $\delta \geq \frac{p + \alpha t}{s_0}$. Consistently, aggregate demand for contents is equal to:

$$D_C = N\left[1 - \frac{p + \alpha t}{s_0}\right]$$

On the supply side, the conduit provider sells network bandwidth to the CP for delivering its products. Supplied contents have been paid off by previous utilizations (i.e. sold to radio or TV programs) and thus contents' marginal costs of production are zero. Moreover, since we assume network truncations to be not congested, their usage marginal costs are equal to zero as well. Nevertheless, NP's marginal costs are different to zero since some active network services are implemented through a Mediation Server. Such services are crucial for implementing a sufficiently high level of s_0 which, if absent, could make market extension to collapse.

For sake of tractability, we assume that active network services' quality is fixed and their marginal costs are equal to c. Consistently, we posit $1 < c < s_0$: this implies that network services' marginal cost is not negligible and reservation prices ensure network costs recovery. Hence, firms' problems are simply given by:

$$\max_t \Pi_{NP} = (t-c)\,N\left[1-\frac{p+\alpha t}{s_0}\right] \quad (1)$$

$$\max_p \Pi_{CP} = [p-(1-\alpha)\,t]\,N\left[1-\frac{p+\alpha t}{s_0}\right] \quad (2)$$

The IP maximizes joint profits with respect to t and p under the assumption of zero subsidies on network services paid to CCs in order to induce them to buy a content.

We have now all elements useful to sequentially determine equilibrium prices and profits in a Pull/Push Model of CD, given respectively by:

$$p^*_{pull} = \frac{s_0-\alpha^2 c}{1+\alpha};\; t^*_{pull} = \frac{1}{2(1+\alpha)}\left[s_0+(1+2\alpha)\,c\right] \quad (3)$$

$$p^*_{push} = \frac{s_0(3-2\alpha)+(1-2\alpha)\,c}{4};\; t^*_{push} = \frac{s_0+c}{2} \quad (4)$$

$$\Pi^{NP}_{pull} = \frac{N}{4}\frac{\alpha}{(1+\alpha)^2}(s_0-c)^2;\; \Pi^{NP}_{push} = \frac{N}{8s_0}(s_0-c)^2 \quad (5)$$

$$\Pi^{CP}_{pull} = \frac{N}{4}\frac{\alpha}{1+\alpha}(s_0-c)^2;\; \Pi^{CP}_{push} = \frac{N}{16s_0}(s_0-c)^2 \quad (6)$$

It is immediate to show that the following Proposition hold:

Proposition 1. *In a Nash Equilibrium for the game given in (1)-(2), we have the following conditions:*

$$t^*_{push} > t^*_{pull} \text{ for all } \alpha \in [0,1] \text{ and } s_0 > 1 \quad (7)$$

$$p^*_{pull} > p^*_{push} \text{ for all } \alpha \in [0,1] \text{ and } s_0 > 1 \quad (8)$$

$$\Pi^{NP}_{push} > \Pi^{CP}_{push} \quad (9)$$

$$\Pi^{CP}_{pull} > \Pi^{NP}_{pull} \quad (10)$$

Proof. Given our assumptions on α and s_0, inequalities (7)-(8) follows directly from a quick manipulation of First Order Conditions (3)-(4). It is easy to verify that by using equations (5)-(6) inequalities (9)-(10) follow directly for all the values of the parameters involved. ■

Proposition 1 shows that in the push model the NP gains a bigger profit than CP, while the reverse is true in the pull model. Consistently with the price competition literature findings (see Amir and Stepanova (2000)), this result shows that there is a *second moving advantage* in both models. Intuitively, the second mover benefits from the possibility to fill in the gap existing between the first mover's price and the contents' consumer reservation price.

If we compare the two models (Push/Pull) with respect to te single providers, we have the results stated in Proposition 2.

Proposition 2. *Push model is generally more convenient for both providers if and only* $\alpha < \frac{1}{3}$. *Formally:*

$$\left.\begin{array}{l} \Pi^{NP}_{push} > \Pi^{NP}_{pull} \\ \Pi^{CP}_{push} > \Pi^{CP}_{pull} \end{array}\right\} \text{ iff } \alpha < \frac{1}{3}$$

Proof. Regarding (9)-(10), it is easy to find that:

$$\begin{aligned} \Pi^{NP}_{push} &> \Pi^{NP}_{pull} \Leftrightarrow s_0 < \frac{(1+\alpha)^2}{2\alpha} = \overline{s}_0 \\ \Pi^{CP}_{push} &> \Pi^{CP}_{pull} \Leftrightarrow s_0 < \frac{1+\alpha}{4\alpha} = \underline{s}_0 \end{aligned}$$

It is immediate to show that $\underline{s}_0 < \overline{s}_0$ for all $\alpha \in [0,1]$. Therefore, it is sufficient to set $s_0 < \underline{s}_0$. However, in order to make the condition $s_0 > 1$ verified, we need to set $\alpha < \frac{1}{3}$ to make sure that $\underline{s}_0 > 1$. If $\alpha \geq \frac{1}{3}$, $\underline{s}_0$ is lower than one and both inequalities are reversed. This concludes the proof. ■

The relative convenience in terms of profits of both models depends from the amount of network services prices is borne by consumers. In fact, in the push model, the network price is bigger: thus when this is heavily paid by consumers this makes the market thinner and produces lower profits for both firms.

After a vertical integration between providers, price decisions are taken simultaneously by the integrated firm. When we maximize joint profits with respect to p and t we obtain that if network services' price are non-negative, equilibrium prices and profits are given by:

$$t^*_{IP} = 0 \tag{11}$$

$$p^*_{IP} = \frac{s_0 + c}{2} \tag{12}$$

$$\Pi^*_{IP} = \frac{N}{4s_0}(s_0 - c)^2 \tag{13}$$

Traditionally, vertical price externalities are internalized eliminating *double marginalization effects*. Nevertheless, contents' price is now larger than what it was with a de-integrated CP in above cases. Comparing, (13) with de-integrated providers' equilibrium profits of a Push model of CD, we can show that

Proposition 3. *With the push model of CD, vertical integration of CD is always an optimal strategy. Contrarily, with the Pull model of CD, vertical integration augments firm's profit if and only if content's quality is low. In case of higher content quality, vertical integration is profitable in the Pull model if and only if a small portion of active network services costs is paid by content consumers.*

Proof. Comparing (13) with sum of profits appearing in (5) and (6), it is easy to get that:

$$\Pi_{IP} > \Pi_{push}^{CP} + \Pi_{push}^{NP}$$

for all values of models parameters. At the same time, for the pull model, we have:

$$\begin{aligned} \Pi_{IP} &> \Pi_{pull}^{CP} + \Pi_{pull}^{NP} \text{ if only if } s_0 < \overline{s} = \frac{4}{3} \text{ or} \\ s_0 &\geq \overline{s} \text{ and } \alpha < \overline{\alpha} = \frac{\left[s_0\left(s_0-1\right)\right]^{\frac{1}{2}}}{s_0-1} - 1 \end{aligned}$$

■

Summing up, vertical integration between content and conduit providers is a profits enhancing strategy if large bandwidth multimedia streams (like real-time data flows) are pushed into the web by providers or small bandwidth contents of low quality can be pulled directly by CCs. However, if a Pull model is adopted by providers for light size contents (like HTML pages or GIF images), vertical integration may involve lower profits if high quality has to be ensured and CCs are supposed to pay (almost all) network services' costs. In this case, internalizing these costs may induce a reduction in network management revenues, not fully compensated by larger selling revenues. Thus, with exception of this latter case, it is likely to predict large marger and acquisition activites in on-line content markets.

4. Vertical Integration in Duopoly: The Role of Active Networking Services

With this setup, we can now provide some insights on the rationale of vertical integration in duopolistic markets, where downstream and upstream price competition takes place. For illustrative purposes, let us deal with the *simplest* case: symmetric providers, perfectly substituable contents and no capacity constrains. The symmetry assumption is reasonable for mass contents usually sold and delivered by large symmetric providers (e.g. AOL and Sprint, Time Warner or Universal). Perfect sustituability is reasonable for certain kind of contents (like news, whether conditions, music video-clipping). Finally, no capacity constraints for providers implies absence of congestion problems for delivering perfectly replicated on-line contents. Traditionally, in this case content demand for each content providers is given by:

$$D_C^i := \begin{cases} D_C \text{ if } p_i + \alpha t_i < p_{-i} + \alpha t_{-i} \\ \frac{1}{2} D_C \text{ if } p_i + \alpha t_i = p_{-i} + \alpha t_{-i} \\ 0 \quad \text{otherwise} \end{cases} \text{ with } i = 1, 2$$

profits without vertical integration are consistently defined. As it is straightforward to show, if no vertical integration occurs, price undercutting leads to the classical *Bertrand Paradox* with contents and network transits priced at marginal costs and zero profits. Moreover, this Bertrand equilibrium holds also in the case of price-competiton between two integrated providers as well as when one integrated provider faces two de-integrated competitors. Invariant conclusions can be drawn for both models of CD as well[7].

Hence, with this market structure, vertical integration between providers is a profit-enhancing strategy only if it creates some *asymmetries* in favour of the integrated firm. These can be due to IP increased ability in performing content-specific-functionalities between servers at lower (technical and/or transaction) marginal costs, or to higher perceived quality by CCs. In both circumstances, an IP is able to monopolize the market getting positive profits.

Therefore, in order to develop a more comprehensive economic analysis of vertical alliances in on-line duopolistic content markets, it becomes important to study the characteristics of such active networking services. This achievement is possible only after a fruitful integration between economics and computer science literature. However, in what follows we are trying to provide some intuition anyway.

With respect to online content delivery, MacLarty and Fry (2001) stress that *data caching* (i.e. an optimization procedure which select an optimal data transport protocol) is a crucial component of *CdQoS*. On-line content delivery usually requires stable network bandwidth together with no interconnection breakdowns. Hence, data caching allows to reduce network download latency or frequent interconnection breakdowns among servers, improving *CdQoS*. Consistently, MacLarty and Fry (2001) propose to use protocol filters, called *proxylets,* to enhance protocol functionalities between servers. Such proxylets can be located on a Proxy Servers linked to CP's server and to consumers' web browsers. The proxy server is a machine which recognizes proxylets and selects optimal data transfer protocols. More generally, they conclude that *active networking* services have to be developed in order to ensure optimal caching and an high *CdQoS*.

There are at least other three kinds of active-network services[8]:

- *adaptation* of media streams format for available network bandwidth. Without this function, a network provider may degrade synchronization of data flows reducing *CdQoS*. Therefore, dynamic distillation of media streams is required to adapt transmissions to network conditions.

- *media scaling,* i.e. the dynamic manipulation of blocks of contents sent through the network at different bit rates. Absence of media scaling augments the probability of network breakdowns, negatively influencing *CdQoS*.

[7] Calculations for these cases are available upon request.

[8] On this issue see Rousseau and Duda (2000) and Harumoto et al. (2000).

- efficient *scheduling* can reduce data loss rates by augmenting synchronization and *CdQoS.*

Quite intuitively, vertical integration between providers is likely to involve better perfomed active networking services. This can easily result in lower network transits' costs or in higher perceived contents' quality by CCs. In both cases, economic and technical asymmetries between integrated and de-integrated providers may phase out.

Finally, it is worth to note that if active-network services' quality is degraded, contents' quality is low and more likely CCs decide for alternative multimedia contents and providers. Thus, in duolopolies a new kind of IPs' discriminatory behavior can phase out at the expenses of non-integrated CPs which ask for network access . An interesting open issue for network economics is to understand what are the consequence of active-network services' quality degradation for competition.

5. Conclusions

In this paper some we discussed some rationales for vertical integration of network and content providers. Because of the lack of literature on this issue, we presented two simple cases: successive monopolies and Bertrand duopolies given well-grounded reasons (i.e. network externalities, lock-in effects, copyright protection etc...) for considering on-line content markets highly concentrated market structures.

The results show that vertical integration between monopolistic providers is a profits-enhancing strategy if large bandwidth multimedia streams (like real-time data flows) are pushed into the web by providers or small bandwidth contents of low quality can be pulled directly by CCs. On the other hand, if a Pull model is adopted by providers for light size contents (like HTML pages or GIF images), vertical integration may involve lower profits if high quality has to be ensured and CCs are supposed to pay (almost all) network services' costs. In such case, by internalizing these costs it is possible to induce a reduction in network-management revenues, not fully compensated by larger selling revenues.

Furthermore, it has been discussed that for symmetric providers competing in Bertrand duopolies vertical integration has some rationales only if it allows to better perform some active networking servers' functionalities. This can create asymmetries between integrated and dis-integrated competitors in favour of the former.

As recently stressed by Rollen and Wey (2003), intense and cross-border merger activites by large oligopolistic firms is a peculiarity of *New Economy*'s markets. In particular, *Machinery and Computer Equipments* and *Business Services* have been the industries with the highest number of mergers during the 90s. This trend raises several issues of interest for network economics. In particular, an important problem is how to sustain competiton in markets where product complementarities, non-covex costs and demand side economies of scale make consumers better off, higher is the degree of market concentration. Our discussion suggests that very likely, in the next decade, many mergers would take place also in *On Line Entertainment* markets.

Like computer ones, On Line contents markets are characterized by network effects, services complementarities and switching costs. Not surprisingly, it is easy to empirically observe an high degree of market concentration in Internet access provision. Moreover, in on-line markets many contents should be monopolistically provided on the Web by labels by using copyright protection. Thus, on-line content markets can be described as concetrated markets with well-grounded tendencies to huge merger actitivies. Once this description is accepted, a reformulation of the above dilemma might emerge.

Given actual conditions, is it socially preferable to block vertical integration waves which reduce CdQoS and generate double-margins ? Or is it rather socially better to accept mergers and acquisition tendencies in on-line entertainment industries, as long as they augment CCs' satisfaction and firms' profits ?

The resolution of this dilemma might involve a serious reflexion on copyright legal protection's extent. In fact, the downloading of a replicable content sold at monopolistic price, is rather different than repeatedly downloading a non-manipulable content. On the other hand, in order to solve this dilemma we need to define a regolatory framework for Internet markets where competition policies are logically inter-twined with inescapable market concentration[9].

[9] In this context, regulation could foster effective competition between different kinds of informative networks (cable TV, satellite, telecoms, fiber-optic and others) or impose common carriage.

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