

Lights and Shadows from Economic Analysis on Net Neutrality and Internet Pricing Policies

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Abstract: Network neutrality constitutes today an emerging branch of economic analysis. This article explores this literature to open the discussion to new economic issues observed from the industry's practical experience that have not been yet addressed by the existing literature.

Key words: Network neutrality, interconnection agreements, two-sided markets, peering pricing policies.

During the first few years, the network neutrality debate lacked rigorous economic analysis, certainly due to the complex nature of the subject itself. However, today there exists a rapidly growing economic literature on the topic; network neutrality has become a lively field of theoretical research. Following the first literature review by SCHUETT (2010), we can identify two main orientations for defining network neutrality within economic analysis: the zero-price rule and the non-discrimination rule.

The zero-price rule refers to regulation where Internet service providers (ISPs) are banned from requesting termination access charges to online content and applications providers (CAPs). Articles studying the zero-price rule are mainly inspired from the theory of two-sided markets. The issue at stake is to determine which side of the market, end-users or CAPs, pays which proportion of ISPs' costs. Further, the objective of this literature is to analyze the impact of pricing schemes on Internet adoption, usage and ultimately content innovation. Articles on the zero-price rule include

(*) The paper presents the views of the authors and does not necessarily reflect positions of Orange.

ECONOMIDES & TAG (2009), MUSACCHIO *et al.* (2009), or LEE & WU (2009).

The non-discrimination rule refers to a regulation where ISPs cannot offer differentiated quality of service to CAPs. In particular, the literature has focused on the role of congestion in the allocation of limited network resources, the benefits of product differentiation and investment and innovation incentives. HERMALIN & KATZ (2007), CHOI & KIM (2010), ECONOMIDES & HERMALIN (2010) and REGGIANI & VALLETTI (2011) have contributed to the subject.

The authors of the articles mentioned above are distinguished economists, who have already given important insights on a potential regulation, yet the road ahead is still long and the network neutrality debate is far from being closed. Authorities and market players around the globe have yet much to discover from the burgeoning economic analyses. But economists could also incorporate more of the industry specific elements to this new field of research.

The objective of this article is to open the discussion to new issues, new ingredients for economic modeling, mainly observed from the industry's practical experience, which have not been yet addressed by the existing literature, and to further give initial intuitions on what economics theory has already asserted in general circumstances.

The following section presents an economic rationale for the current unsustainable Internet interconnection model, one of the alleged underlying causes of the network neutrality debate. Then we develop on efficient pricing properties that the Internet, as a network, should have. The third part deals with the application of two-sided markets literature to network neutrality. This section discusses the suitability of specific assumptions commonly used with the two-sided markets literature. It exposes industry characteristics that should be taken into account such as the role of end-users in the innovative process or the asymmetric nature of information between CAPs and end-users respect to the cost of traffic delivery. Likewise, the fourth part contributes to some missing aspects of the non-discrimination rule literature. In particular we discuss the features of managed services. The final section concludes.

■ The limits of settlement-free peering agreements

In the early Internet days, as FARATIN *et al.* (2008) describe, the entities forming the Internet followed a simple hierarchy, where local and regional networks were connected by a single government-subsidized backbone. The emergence of the commercial Internet in the 90s gave rise to a relatively more complex interconnection system where two types of interconnection agreements were practiced: *peering* and *transit*.

In a peering agreement, two network operators interconnect to provide access to each other's costumers. A settlement-free peering is an agreement without any financial exchange where network operators' revenues proceed only from networks own customers; for this reason peering is also called *Bill and Keep*, or *Sender Keeps all*. A paid peering is identical to free peering in terms of the technical interconnection practices but traffic is no longer exchanged without payment. As we will see below, a monetary compensation can be practiced in case of asymmetric traffic exchange.

In contrast to peering agreements, transit agreements resemble a client-server model. A network operator provides access to and from the entire Internet to its client network in return for a monetary settlement.

During the first years of the commercial Internet, network operators differed only on their *size*. The size of a network, as FARATIN *et al.* (2008) mention, could be measured either by the network's geographic scope, its total rates of traffic across boundaries, or its number of attached customers. Size-wise symmetric networks were led to peering agreements in view of several potential benefits, thus peering emerged as one of the most important and effective ways for networks to improve the efficiency of their operations.

Peering agreements are efficient when the traffic exchanged is symmetric

NORTON (2001) develops on operators peering decision-making process and on the benefits of this type of interconnection agreement. He highlights two clear-cut motivations for two symmetric networks to peer: Lower transit costs and lower latency.

Transit service costs represent a high proportion of variable costs for network operators. To reduce recurrent transit costs network operators might find it profitable to cover the fixed costs to set-up the interconnection link at the peering point.

Additionally, direct interconnection with a network enhances the experience of network operators' customers as the traffic destined for peering partners traverses shorter paths, reducing the distance and thus decreasing the time delay of traffic arrival. NORTON (2001) cites an example of traffic between the United Arab Emirates and Saudi Arabia that traversed unnecessarily an overloaded exchange point in Washington.

However, the scope of benefits of peering agreements are not limited to lower transit costs and lower latency, they also give rise to global efficiency gains. In the backbone, two similar size network operators with symmetric traffic bear symmetric traffic operational costs.¹ In effect, it is reasonable to admit that for similar size networks the cost of the packet delivery incurred by network A is similar to the cost incurred by network B when it delivers a packet coming from network A. If the traffic is balanced, the costs are similar: both networks "mirror" each other. Given that in a peering agreement the only financial compensation proceeds from network's own customers, both networks have incentives to reduce their operational costs. In other words, symmetric traffic exchange with peering agreements induces efficient internalization of costs, which generates efficiency gains for the entire system as furthermore, transaction costs are reduced.

But this mechanism is achieved only when traffic between both networks is symmetric.

Current highly asymmetric traffic exchange biases the efficiency of peering

One of the main reasons to refuse a settlement-free peering agreement is traffic asymmetry. If traffic or network investments are asymmetric, one party bears a higher portion of the costs as a result of peering.

¹ For example the maintenance and upgrades of connection links, variable costs of traffic routing, etc.

Moreover, asymmetric peering creates market distortions. Indeed, the network that sends higher traffic volumes faces artificial low costs, as it does not bear the costs of delivering its traffic to its peer network. Then, the perceived low cost gives the network operator an artificial competitive advantage as it is able to set lower prices in the market, which at the same time attracts more customers. Hence, the traffic emitted by perceived low-cost operator expands, which induces an even greater asymmetry ratio. This mechanism gives rise to a "snowball" effect. As a consequence of the snowball effect, market prices for traffic delivery reach artificial low levels leading to inefficient consumption.

The inefficient mechanism that we have described can be seen in current traffic exchanges, which are highly asymmetric due to the specialization of network operators.

In effect, the Internet has developed to a configuration where network operators of the same size are no longer homogeneous in respect to the traffic they deliver. This is caused by the emergence of networks operators that specialize either on hosting CAPs or on delivering traffic to end-users (frequently called "eyeballs"). For example, Comcast, AT&T, Orange, or Vodafone constitute eyeball networks, whereas Cogent and Level 3 are clearly CAP networks hosting large content providers.

Inevitably an eyeball network and a CAP network generate asymmetric volumes of traffic. Today this asymmetry is exacerbated by the emergence of high-bandwidth services, such as streaming video and Internet TV-based services, but also richer content as part of social networking sites and cloud computing for business services delivery.

Eyeball and CAP networks also differ on their costs for delivering traffic. Eyeball networks incur higher delivery costs due to last-mile network operation and maintenance. In the mid/short-term these networks will also face extremely high lump costs due to the migration from the copper local loop network to last-mile fibre networks. The difference of delivery costs increases the price difference and reinforces the snowball mechanism described above.

To sum up, the emergence of high-bandwidth service, in particular streaming video, hosted by specialized CAP networks has led to highly asymmetric traffic exchanges between formerly homogeneous peering partners. This has resulted in equilibrium where costs are not properly

internalized and where artificially low prices for traffic delivery induce, as it will be discussed below, excessive growth of traffic volumes.

In theory, a perfectly competitive market should result in bargaining of interconnection agreements that compensate for these asymmetries where all market players can adapt to the growth of traffic. In reality this is not the case, difference in bargaining power has only contributed to higher traffic asymmetries, as Internet access markets are more competitive than other parts of the Internet value chain,² to the point that analysts have concluded that the current Internet economic model is unsustainable.

Today's Internet economic model is unsustainable

Recent traffic growth and mid-term forecasts raise serious challenges of the Internet model in the future (see Cisco Visual Networking Index June 2011 and A.T. Kearney, 2010): Internet traffic delivered via fixed networks is growing at 35% p.a. and at more than 100% for mobile networks. The traffic growth goes beyond the already impressive technological progress rate of information technologies, 20 to 30% and about 50% for mobile, as assessed by KOH & MAGEE (2006) and AMAYA & MAGEE (2008). This strong growth is driven by the increasing availability of new high-bandwidth services, by an increasing penetration of multimedia devices, and by changes in usage patterns supported by flat rate offers.

Compared to past traffic growth, the Internet ecosystem today is characterized by an increase in video applications. However, the main difference for eyeball networks in Europe is that they now battle in competitive and mature access markets where Internet adoption has already reached saturation. Furthermore, as generally retail rates are flat, networks face limited revenue growth rate.

As a consequence, there is a gap between the rate of data growth and the rate of networks revenue (and thus the rate of networks investments). Maintaining current levels of returns in the telecommunications networks while investing to maintain current fixed and mobile network performance in Europe would require additional revenue of €28bn per annum by 2014; which represents about 10% of today's total market (A.T. Kearney, 2010).

² A complex issue that will not be treated by this paper.

The issue of additional revenues has a rightful place within the network neutrality debate. Market players have argued that a revision of interconnection economic models could partially answer some of the issues raised by network neutrality. Paid peering, the interconnection agreement equivalent to peering with respect to technical specifications but where the traffic is no longer exchanged without payment is an alternative to highly unbalanced traffic patterns. Market players have introduced the idea of agreements where settlement-free peering is practiced up to a certain level of asymmetry (for instance a 1:2 ratio) and thereafter traffic is charged at a certain level.

The economics of data interconnection is a complex issue. Academic work has so far focused on the topic of interconnection of voice networks. There is a lack of formal analysis on the reason behind the failure of interconnection bargaining process between operators that has led to the current unsustainable state of the Internet. However, it is likely that part of the explanation is related to unbalanced obligations between highly regulated Internet access provisions in Europe and unregulated though very concentrated Internet application or content activities.

■ A price structure for an efficient network

As presented above, the growth of data traffic on the Internet increases at an unsustainable rate, the necessity of new investment on network capacity in order to support the additional traffic is evident.

There are a number of possible solutions that may help restore the link between traffic and capacity, increasing funds available to invest in the fixed and mobile Internet infrastructure. Their impact and implementation feasibility would need to be further explored but can be summarized into four main options:

- raise additional revenues by modifying retail pricing schemes within the current commercial model;
- introduce a reasonable data-conveyance charge to be paid by traffic senders (based on total volume sent or peak traffic) for asymmetric traffic covering a fair share traffic long run marginal cost. This would not make a significant difference for small or medium size CAPs who already pay for transit or CDN services;

- develop optional end-to-end interoperable managed services besides the best-effort Internet ;
- develop technical and commercial partnership on a bilateral basis between connectivity providers and CAPs.

In what follows, we examine in the light of economic analysis the second option: The introduction of data charges in peering settlements where the charge is applied only when traffic exceeds certain asymmetry levels. The third and fourth options relate to the "non discrimination rule" of the Net neutrality debate, they are briefly addressed in the last section.

The price of asymmetric traffic should cover its pure long run marginal cost

In general, economic theory affirms that it is efficient to price a product or service at its appropriate cost. Pricing above costs creates welfare losses arising through unexploited gains from trade. Pricing below costs induces, in this case, excessive consumption that saturates the network. For telecommunications networks, the appropriate cost of traffic is the long run marginal cost. Whenever traffic exchange is symmetric, a settlement-free peering induces equivalent incentives to become as cost efficient as whenever traffic is priced at long run marginal costs.

Putting aside dynamic effects such as innovation and investment incentives, flat rate pricing schemes result in inefficient Internet network usage in a plain simple economic sense where the volume of traffic emitted is not correlated to the value it generates for society. For instance, file exchange via peer-to-peer applications or video streaming require large network resources compared to the value they create, in particular for copyright holders.³ However, if one considers that the content of the traffic on Internet maximizes social welfare, the problem of inefficient use of the network prevails.

The inefficiency of network usage is caused by the nature of the Internet's protocol to exchange traffic. The first come first served protocol implies a general cooperative behavior of Internet actors: if network congestion is detected, all traffic emission should be reduced. Yet, it is

³ For a detailed illustration of the disconnection between value and revenues see Vodafone Policy Paper: "The Economics of the Internet" (2010).

individually beneficial to increase one's traffic, or at least to not reduce it, in order to have one's traffic delivered first. It has hence been observed that CAPs have more incentives to not act cooperatively, saturating networks when they are not proportionally charged to the traffic they emit.

Furthermore this inefficiency is exacerbated by CAPs' lack of incentives to become cost-effective. The IT sector is characterized by technological progress, investment and adoption of new technologies that continuously allows enhancing the performance of the transmission and coding of data. Nevertheless, CAPs will only adopt more efficient coding of their data if the efficiency gains are internalized, that is, when they are accountable for the volume of traffic they emit.

The lack of adequate price for traffic creates opportunity costs due to congestion

As previously developed, the current Internet ecosystem and the lack of proper pricing signals threatens the sustainability of the overall model as the increase in traffic leads to an increase in unilateral traffic transmitted by players higher up in the value chain.

Massive transmissions of data have the potential to saturate networks creating opportunity costs for the society as a whole. Increasing traffic leads to problems in quality of service due to network congestion, which in its turn penalizes emerging services developed by other actors and end-users. Moreover, the lack of an appropriate price signal for traffic generation leads to financial problems related to network sizing, problems linked to the allocation of resources shared between users of Internet access and users of the Internet as a carrier and difficulties in establishing appropriate price structures within the CAPs market.

For these reasons, economic analysis should be concerned with the effects of congestion. As mentioned in the introduction, the non-discrimination rule literature has introduced congestion considerations into the economic analysis, yet congestion and allocation of available resources should also be taken into account when studying traffic pricing and interconnection schemes.

That being said, most economic research on network neutrality makes abstraction of the fact that the Internet is a network of interconnected networks. In order to simplify this very complex ecosystem and to deal with

workable models, economists have made the assumption that only a network operator (or maximum two competing network operators) provides the entire Internet service to end-users and CAPs. The literature on the zero-price adopts this view. The next section briefly reviews it and highlights some missing considerations, in particular with regards to conventional assumptions that might not necessarily hold in this industry.

■ The missing points of the zero-price rule literature

The zero-price rule refers to a regulation where ISPs are banned from requesting termination access charges to CAPs. This literature is mainly inspired from the economics and methods of the two-sided markets literature. The concept behind it is that the pricing structure, i.e. which side of the market (CAPs or end-users) pays which proportion of network costs, has an impact on Internet access adoption and usage. In this framework, the efficient pricing structure subsidizes the side of the market that is more sensitive (or prone) to a price increment or that induces a greater positive externality on the other side.

Two-sided market analysis applied to network neutrality

Under two-sided markets analysis, economists conclude that without a zero-price rule less content will be available on Internet but consumers will pay less for Internet access. Total welfare effects are not clear-cut and they depend on the parameters of each particular model.

ECONOMIDES & TAG (2009) have a critic view on departing from the zero-price rule. In line with LEE & WU's (2009) analysis, they argue that it is best for society that consumers subsidize the cost CAPs generate. They argue that without regulation, a network operator would set a restrictive charge for CAPs, excluding far too much content, which reduces the value of the Internet. However, their modeling seems to fail robustness analysis. As CAVES (2010) argues, their conclusions are only valid for a limited range of parameters. They also suppose that CAPs value more an additional consumer than the other way around. This in turn implies that a social planner would not completely subsidize CAPs as the zero-price rule suggests.

MUSACCHIO *et al.* (2009) incorporate in their analysis investment on the quality of the network and on the variety of CAPs. They find that if there is no regulation that forbids ISPs from freely charging CAPs, ISPs overcharge CAPs. In effect, each ISP captures the full benefit of this charge without bearing the full cost of a decrease in the variety of content available to consumers. A limiting assumption is that network operators are local monopolies, which is inconsistent with European access markets.

These analyses only encompass polar cases: ISPs charge CAPs without restriction or they are prohibited from doing so, they do not study intermediate regulations where the charge would be regulated at appropriate costs. Furthermore, these articles seem to miss some important points.

Market power issues

These models assume that CAPs are price takers and have no bargaining power. This is clearly not the case.

In a two-sided market framework, competing ISPs bring on board more consumers by offering must-have online content. The crossed externality provides dominant CAPs in the online market bargaining power in the interconnection market. Actually, large, popular, over the top CAPs often impose their market power to agree in settlement-free peering arrangements or transit agreements at rock-bottom fees. In some cases, these large CAPs induce the traffic that is most costly for ISPs and pay the lowest delivery prices.

Market power issues on the content side should also be explored in order to incorporate this relevant aspect of the Internet ecosystem.

Innovation and content steam from end-users (more than from content providers)

The particular history of innovation on the Internet is the recursive tale of end-users, who create, in principle for their own particular use, tools and services relevant enough to be subsequently widely adopted by others.

We observe this in the creation of the Internet itself. The ARPANET, the first network based on packet switching protocols, founded by the US Department of Defence had the objective to survive nuclear attacks in the

context of the 1970s war context. The initial purpose of what now has become the greatest economic space was far from any commercial purpose. Another example is the World Wide Web. Tim Berners-Lee, a physicist working at the European Organization for Nuclear Research, conceived the use of interlinked hypertext to facilitate the access of academic information. Similarly, the well-known history of Google, two students in a garage created what has today become a universe of services. The examples of innovation issued from end-users follow: Facebook, Open systems like Linux, technological innovations like VCL multimedia player, network sites like Groupon, all provide examples of end-user-generated innovations.

Although it is not new that "good ideas" most often come from intermediate or end-users (and not mainly from producers)⁴ the open characteristic of the Internet in the numerical age has allowed them to implement these ideas and then make them available for other users.⁵ It is in this light that economists should also assess the impact of pricing schemes on innovation and content production in the Internet.

Two-sided market models assume that participants on both sides of the market have different natures and that potential platform participants are exogenously determined. However the emblematic examples listed above indicate that a critical proportion of potential CAPs actually stem from end-users. The conclusion of the zero-price rule that asserts that higher fees for content providers result in less content does not take end-user innovations into account, which actually do account for a critical portion of the Internet applications and content.

Price signals should be sent to the most informed party

Another interesting ingredient that is missing is related to end-users incomplete information on traffic delivery costs.

As previously discussed, achieving an efficient match between traffic and capacity, will require new pricing and commercial models in order to set a price for use of Internet resources (core, aggregation resources as well as for mobile network part of access resources) at a level which covers

⁴ The theory of the "lead user" of Von Hippel illustrates how companies research future successful products by observing well-positioned users in the market.

⁵ Other industries do not allow the implementation of innovative ideas by end-users.

incremental costs. The price signal to cover costs should be sent to the most informed party.

A consumer that uses his smartphone or clicks on a link to open a webpage does not know *ex ante* the automatic stream of updates or the exact content he will receive. He is even less informed on the costs these updates and content represent to the network. As already observed, application providers send a non stop stream of updates and add-remunerated content providers have no difficulty in sending with the content required many flashy add-bans to attract the consumer's attention. If the market evolves to usage-based pricing, the traffic not required but charged to the consumer would create commercial and legal impasses.

Retail consumers have today a limited power to control the traffic they receive from CAPs. They are inadequately equipped to technically influence the efficiency with which the network is used to deliver the service. On the other hand, content and applications providers have the expertise and the ability to influence the volume of traffic. As a consequence, signalling effect will most likely be more efficient when sent on the content provider side versus the consumer side of the market.

■ The missing points of the non-discrimination rule literature

The non-discrimination rule, as described in the introduction, refers to a regulation where ISPs cannot offer differentiated quality of service to CAPs. The literature has focused on the role of congestion in the allocation of limited network resources, the benefits of product differentiation and investment and innovation incentives.

Similar to the zero-price rule, the literature on the non-discrimination rule has mostly considered a monopoly ISP, ignoring coordination issues of quality implementation between interconnected ISPs.

HERMALIN & KATZ (2007) is the first paper published on the subject. They model an ISP that proposes different levels of managed services to CAPs. In their analysis, the ISP does not know the value a CAP offers to consumers. By using a principal-agent screening model they find that if higher fees were proposed for a better quality treatment, only the high-value CAPs would subscribe to high quality treatment, mid-value CAPs would

demand medium quality treatment, and so on. They conclude that a non-discrimination rule, a rule that restricts the platform to offering only one level of quality of service would most likely reduce welfare.

CHOI & KIM (2010) introduce competition between CAPs into their analysis. In their model ISP's network is saturated, therefore offering priority to one content reduces the quality of a rival content. The ISP exploits the rivalry between contents in order to extract their profits when proposing quality of service. Their principal result relates to ISP's incentives to invest in network capacity. Investing in network capacity increases end-users' willingness to pay for access to the Internet but at the same time it decreases CAP's willingness to pay for priority services. Welfare of these effects can go either way. They conclude a non-discrimination rule does not necessarily reduce network investment incentives. However in their analysis demand for content is inelastic. If a capacity increase induces more content consumption in absolute terms, the negative effect on investment caused by CAPs' willingness to pay would in turn be reduced.

Dealing with market power on the content side, SAAVEDRA (2010) models a CAP with bargaining power who can propose joint investments to two competing ISPs. Advertising revenues allow for a higher quality of the delivery of content whenever allowed by regulation. If no agreement is concluded between the CAP and an ISP, the content is still delivered at best-effort quality. It is found that a CAP with high bargaining power extracts profits from the upgraded service quality.

The other paper that deals with market power is REGGIANI & VALLETTI (2011). They find that in the short run the non-discrimination rule increases provision of small CAPs whereas it decreases the number of applications offered by a large CAP. In the long run, the ISP adjusts capacity to maintain the level of congestion. In all, regulation leads to lower supply of capacity and overall content, but it also fosters CAPs entry.

All these papers are concerned with quality differentiation. In practice there are several ways to propose quality of service in communication networks. Providing quality through differentiation at Internet packet transportation level, as assumed in this literature, is highly challenging. Instead, network operators as well as specialised Internet providers⁶ actually propose managed services in addition to best-effort Internet, with

⁶ In particular Content Delivery Networks such as Akamai.

specific technico-economical characteristics which would require specific economic modeling features.

Pricing quality differentiation of Internet packets delivery would be very challenging

It would be challenging for a network operator to price quality differentiation of Internet packets delivery, due to traffic engineering considerations which in a nutshell, are the following ⁷:

- as long as the traffic demands do not exceed available capacities, the network is nearly transparent and the quality is good for all traffic
- as soon as traffic demand exceeds capacity, absent traffic management, the throughput drops dramatically for all traffic until sources stop generating traffic
- the network operator may efficiently manage this congestion phenomenon if and only if it applies admission control of traffic at the "flow" level. The notion of flow here may be identified with a service demand from an end-user. ⁸

In other words, an operator cannot guarantee the quality of service if it operates purely at the packet level and if it does not identify demands of services by end-users. However, if the operator identifies demands of service by end-users, this service is no longer delivered via the public open Internet, but it is rather a "managed service", that is a service identified and managed by the operator within the network.

Quality differentiation with managed services requires specific modeling features

There is a substantial difference between the implementation of quality of service within the public Internet via managed services. With managed services, the ISP has knowledge of the nature of the content or application provided, whereas within the public Internet he does not.

⁷ See ROBERTS (2004) for in depth analysis.

⁸ One reason for this is that the statistical processes of service demand arrivals can be usefully modeled for traffic engineering purposes, whereas the statistical processes of packets arrivals are extremely complex and defy modeling and engineering techniques.

Consequently, these two practices imply different costs characteristics and different allocation of resources.

For instance, the characteristics of a managed service are rigid while best-effort Internet access allows flexible service innovations at the extremities of the network. But in return managed services are produced in the network more efficiently. They consume fewer resources and at the same time can guarantee quality. This is because the operator can optimize the operation of the network while satisfying the services requirements. For instance, mobile operators have optimised network operations to accommodate voice telephony down to the radio transmission layer, or fixed access providers have implemented multicast routing protocols to provide IP-TV services, massively saving common transmission resources. Managed services provided "over the Internet", such as Content Delivery Networks, also combine improved quality of service and resource savings. The price to pay for these benefits of managed services is in the service specific interface and the need of a specialised command and control layer to manage service demands and capacity reservation at the transport layer.

Therefore the quality offered by managed services is not undertaken at the expense of the capacities available over the public Internet.

The final consideration relates to investment and expansion of network capacity. One can agree that the zero-price rule deals with pricing schemes to cover ISP's variable costs, whereas the non-discrimination rule deals with network investments that generate fixed costs. The latter assumes that the ISP effectively provides differentiated services, identifies the value of these differences for end-users and prices its services accordingly. In this respect, this literature is more relevant to the provision of managed services in parallel with best-effort Internet than to the differentiation of quality of services within the Internet. Therefore it should incorporate the appropriate modeling features specific to managed services. A paramount lacking consideration is the critical role of operators' managed services in financing enhanced common infrastructure which have a positive impact on best-effort Internet quality of service. This is observed empirically for instance in the fixed access market where for instance technologies such as Gigabit Ethernet, ADSL 2+ and now VDSL, Docis 3.0 or FTTH are deployed by ISP for their IP-TV services but have dramatically improved the quality of the Internet access service.

■ Conclusion

During the past few years, the Net Neutrality debate has motivated the emergence of a specific economic literature.

In some cases, this literature has produced sophisticated mechanisms based on simplistic representations of reality; which results in paradoxical conclusions with respect to classical economic principles such as a zero-price rule or a prohibition of a socially efficient product differentiation.

A more precise analysis of the underlying mechanisms at work in the Internet markets would uphold more conventional conclusions:

- the need for traffic prices covering their marginal costs so that the supply of capacity meets traffic demand;
- the risk of distortions of competition in the absence of proper internalization of costs in a system with artificially maintained peering agreements whereas the exchange of traffic is asymmetric;
- the efficiency to allocate the costs generated by traffic to who generates it and who best controls it;
- the usefulness of allowing an operator to optimize the productive efficiency of a service through its network whenever he masters the characteristics of this service;
- the essential role of end-users in the production of content and services, the stepping stone of innovation and net neutrality.

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