Estimating Market Power in the Internet Backbone Using Band-X Data

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June 2003

DAE Working Paper No. 0332

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June 10, 2003

*Emanuele Giovannetti acknowledges the support from the ESRC grant R000238563. He also wishes to thank the participants to the Third CEPR Conference on Applied Industrial Organization, Bergen 2002, for their useful suggestions. We would also like to thank Alessio Sancetta, Joerg Lepler, Soykan Soyukayli, and Band –X for their useful help. The usual disclaimer applies.

1 Introduction

1.1 The Regulatory Debate on International Internet Connectivity

International regulatory authorities are devoting increasing attention to the problem of Internet Connectivity. The International Telecommunication Union (ITU)[1] , for example, is recommending the practice of basing Internet connectivity charges on bilateral commercial agreements, however taking account of "the value of elements such as traffic flow, number of routes, geographical coverage and cost of international transmission ...". The issue of whether, or not, to apply some form of ex-ante regulation has seen conflicting opinions between some Asian Pacific Countries and the U.S., the main disagreements being on the degree of competitiveness of the Backbone market and on the fairness of its connectivity tariffs. The EU now sustains that existing commercial agreements have led to the establishment of effective competition in the market for the Internet backbone connections. Hence ex-ante regulation of connectivity prices should only be considered for those countries where a dominant incumbent operator has the control of the local access market, should this not be the case the monitoring of the backbone market should only be the subject of competition policy.

On the other hand, countries[2] arguing for the need to regulate backbone interconnection tariffs along the lines of international telephony settlements, base their view on the evidence of asymmetric treatment of peering[3] and transit[4] policies implemented by the major backbones and on their adverse consequences for developing countries. The distinction between peering and transit agreements, sometime described as asymmetric network access discrimination, is predominantly based on measurements of network size and traffic[5] .

Traffic and network asymmetries are the results of the hierarchical structure and topology of the Internet. This has been changing rapidly: while the original Internet architecture was strongly US-centric, due to the historical legacy of the initial Internet development, a contrasting centrifugal process is taking place. This has mainly been driven by: a) the investment wave in backbone infrastructure; b) the cultural and linguistic differentiation of web contents; and c) by the application of new technologies and practices such as: caching, multi-homing and mirroring[6] . Because of these features, Internet traffic exchanges are losing

[1] See the debate on ITU Recommendation D50

[2] See in particular Peoples' Republic of China Contribution 16 to the ITU Recommendation D.50.

[3] "Peering has a number of distinctive characteristics. First, peering partners only exchange traffic that originates with the customer of one backbone and terminates with the customer of the other peered backbone. ... As part of a peering arrangement, a backbone would not, however, act as an intermediary and accept the traffic of one peering partner and transit this traffic to another peering partner. " Kende (2000)

[4] Transit arrangements occur when one backbone pays another backbone to deliver traffic between its customers and the customers of other backbones

[5] See for example UUNet at http://www.worldcom.com/uunet/peering/

[6] Caching: storaging of already accessed data; multi-homing alternative routing can be

their geographical link to specific physical places, and this is eroding the original U.S. location advantage. In fact we are witnessing a de-agglomeration process of the Internet traffic, which has very interesting consequences in terms of the competitiveness of the backbone market and on the competition policy versus ex ante regulation issue.

The new European Regulatory Framework[7] reflects this view and, while providing the means to enforce fair Internet access for local ISPs, it does not suggest to introduce ex-ante regulation for the sector. The emphasis of the European Directive lies, instead, on general competition law and on the ability to detect, and punish, potential market dominance and its abuse. The focus is hence on the need to monitor, rather than to regulate, the market for International Internet Connectivity and its evolution.

This monitoring task, faced by competition authorities, is particularly daunting for the market of Internet connectivity. This is particularly so when it comes to defining the relevant market, both in terms of product space and of geographical extension; ascertain the degree of market power of single competitors; monitor the evolution of prices and their geographic differentials; evaluate the existence of entry barriers; and detect anti-competitive behaviour or quality based non-price discrimination. The main problem being the elusive nature of the commodity traded, wholesale transmission of information packets, along routes which are often recalculated at each step (hop), of the transmission process. While, indeed, it is easy to calculate the traffic exchanges for traditional telephony, which travel along a dedicated circuit, and to verify the associated economic transactions; new and different tools are required to trace Internet traffic flows when, for example, even a single e-mail from Cambridge to Helsinki is decomposed in many sub-messages which may, or may not, reach the final destination travelling across different routes and networks while some of the network crossing are for a fee and others take place for free.

Cave (1999) also raised the issue about the possible problems and/or desirability of having some degree of market power and hierarchy in the backbone. The denial of free peering to small ISPs is, in facts, at the same time solving a free riding attitude that could potentially lead to inefficiencies and congestion, and posing a threat of anti-competitive behaviour.

Possible ex-ante regulatory measures like obligation to peering, regulation of transit prices, monitoring/prohibition of vertical integration between IBPs and ISPs may induce distortions and are particularly worrying in the case of the Internet, which has shown spectacular growth and diffusion in absence of regulation.

A subtler issue concerning regulators, and therefore final users, relates to the quality of the interconnection provided. Quality differentials are an indicator of market power asymmetries since degraded quality of interconnection

arranged between origin and destination, and mirroring: geographical or backbone multiplication of a web site's contents.

[7]See The Directive on "Access to, and Interconnection of, electronic communication networks and associated facilities" [Official Journal 2002].

can be a powerful form of non-price discrimination in a concentrated industry. Cremer, Rey and Tirole (2000) indeed modelled these aspects of quality competition for the backbone market and analysed a "targeted degradation" strategy where the larger backbone lowers the quality of interconnection to its smaller rivals. Interconnection quality depends indeed on many aspects of the network like its capacity, architecture and the number of peering, private and public, agreements. Hence a crucial aspect of the backbone market revolves around a mainly technical question, "How hierarchical is the Internet Backbone?"

An answer to this question requires the definition of the vertical boundaries of the relevant market to analyse, which in turn affects the determination of the geographical ones: how connected are the different national regional markets for Internet transit, and where should we draw a line when appraising their competitiveness?

The recent investment wave following the liberalisation of the European Telecoms market has dramatically redesigned the Internet connectivity maps and recent Industry reviews by Oftel (2001) and OECD (2002), suggest that there has been a change in the formerly vertical U.S.-centric backbone architecture. The rapidly changing geography of the cyberspace requires therefore a continuous scrutiny since its forms, links and borders define the need for, or the irrelevance of, public intervention in this industry.

1.2 Our Paper

Estimates of market concentration in the Internet Backbone can provide very different conclusions depending on the measuring approach used. For example[8] *revenue based* estimates present serious problems due to the mixing of revenue data from different Internet segments, and are particularly misleading for vertically integrated backbones. *Traffic based* market share measurements are particularly challenging, given the proprietary structure of the backbones. *Routing techniques* for the estimate of backbone market shares are based on an annual survey counting the upstream interconnections of ISPs carried by Boardwatch[9] but have been criticised for not considering the individual relevance of these connections. Finally a *network architecture based* approach[10] considers International Internet Connectivity solely on deployed and operational bandwidth. In this paper we explore an economics, *price-based,* perspective to complement existing metrics techniques used to assess market power, and its potential abuse, in the Internet backbone. Our approach is made possible by the appearance of Online Internet Transit (OIT) trading places in the market for Internet connectivity. OITs allow bandwidth trading through a centralised process with transparent prices while providing Quality of Service information. The immediate consequence of the appearance of these market operators is that while data on pricing and quality of IP transit were often specified in bilateral

[8] For a comparison of different approaches see Abramson [2001].

[9] Boardwatch ISP directory provides a count of the upstream interconnection for the providers, this have been used by the DoJ in its main antitrust inquiries .

[10] This data are collected by Telegeography, Inc.

contracts and kept confidential, now prices are becoming available and can be used for benchmarking the industry. For example the Band-X trading place provides daily prices for monthly Internet transit at different bandwidths, from its trading floors in London and New York.

The competitive impact of OITs on the entire transit market can be of extreme relevance: a lowering of the Internet access prices could enhance Internet penetration, since unconnected consumers might be willing to do so at a reduced price. Increased penetration rates are a precondition for e-commerce and the provision of e-services expansion, and this will have an more general impact on society as a whole, for example by providing information opportunities independently of the geographical area, as long as there is a good Internet connectivity. ISPs, which operate in a highly competitive market, could benefit from the increased demand while enjoying reduced uncertainty and volatility of their costs, and investors and financial institutions would be able to protect themselves from the financial risks through a liquid and transparent market and forward prices. Regulators finally will be able to obtain relevant information for benchmarking the interconnection conditions in the backbone industry.

Our work focuses on the following issues:

We start by comparing the connectivity prices in the I.P.transit markets of the Band-X London and New York on-line trading floors. This is relevant in defining the geographic scope of transit markets which is a preliminary step in antitrust investigations.

We then focus on the I.P. quality indexes to see whether the price convenience implies a lower connection quality.

Our main empirical contribution is the results of a panel data regression which show that the little price variance that there is, is mostly explained by the companies' dummies. This indicates that these specific markets are not very competitive, and that brand effects play a major role since price variations are only marginally affected by qualitative dimensions. Interestingly, the sign of the coefficient is not necessarily the 'right' one. This suggests again that the market is not very competitive since companies with high prices are often able to supply an inferior service.

2 The Internet supply side

The supply side of the Internet has players that can be divided into functional categories[11]:

Internet Service Providers (ISP's). These provide access to the net through personal, business, or institutional accounts.

Network Access Points, (NAPs) and Internet Exchange Points, (IXPs). These form the physical interfaces between networks and can be further divided into public and private bilateral ones.

[11] It is however important to keep in mind that overlap of these functions are often observed, also because of the recent trend in vertical integration, and mergers in the industry.

Internet Backbone Providers (IBPs). They carry data traffic, across long distance on fiber optic cables. At each node they provide routing of the information packages to direct each incoming message to the next step of its path. Backbones are usually classified as Tier 1, 2 and 3 depending on their relevance and connectivity strength. This hierarchical classification is however under scrutiny, both because of the appearance of new technologies and because of the rapid expansions of the connectivity maps of non U.S. backbones which are now often able to offer end to end connectivity, without necessarily depending on the original Tier 1 U.S. ones[12] .

Each single network is connected along two dimensions with the rest of the net: by sharing the same Transmission Control Protocol/Internet Protocol (TCP/IP), the communication protocol providing a common language for computers to exchange information, and through the physical network interconnection points. Traffic growth and commercialization has led much of this interconnection from being carried at NAP's to move towards exchanges at bilateral interfaces. However, in recent years new IXPs are emerging in Europe and they are playing an increasingly relevant role for the intra-European traffic routing[13] .

2.1 Linkages

Consider an end user, A, he connects to a Point of Presence (POP) of its Internet Service Provider. This connection can take place through dial-up, ASDL, Cable TV, or dedicated access. If the information exchange, communication, is between A an other end user and /or web site, B, connected to a different ISP , then A's ISP needs to lease lines to transfer A's message from its POP to either a NAP or an Internet Exchange Point. If such point is shared by the sender's and the receiver's ISPs, then the path is decided, otherwise the IP protocol will evaluate the path, for each single information packets, to reach the B's ISP's Point of Presence. This structure of direct or indirect connections between ISPs, NAPs and IXPs can be repeated many times depending on the actual distance, in the network topology, between the two users, A and B. Long Distance connection is finally provided by backbone operators. The entire route is recalculated at each router, and the actual transmission process is carried by many different ISPs located at different hierarchical levels. The multi-ownership of different segments, of the routes used to exchange information between different end points of the Internet, is one of the features of the Internet architecture generating difficulties in understanding its pricing structure.

[12] For a detailed analysis of the development and construction of these end to end networks see OECD [2002].

[13] See for example the European Internet Exchange Association website: http://www.euro-ix.net/. For an analysis of the role of IXPs on the agglomeration in the Internet see Giovannetti , Neuhoff and Spagnolo (2003).

2.2 The price of Internet Connectivity

While the rapidly expanding number of IXPs, particularly in Europe simplifies the information package routing, by reducing the number of links and the average distance travelled, the connectionless nature of the Internet still makes the price formation process extremely more complex than in traditional telephony.

Interconnection charges among backbone operators have been predominately of the settlements-free type, for peering, while money is usually paid for transit arrangements. The transformations taking place in the Backbone market in terms of capacity, switching technology and mergers are changing the incentive compatibility of existing pricing systems.

The upstream connectivity costs for an ISP can be divided into two main classes, the bandwidth costs required to connect to peering or exchange points and the transit charges when the data traffic leaves the original network outside a peering agreement. On many key routes bandwidth prices, relevant for reaching the Internet connectivity point, have been dramatically reduced as a result of technical innovation and stronger competition. An ISP in need of connectivity can buy it from one of these locations and its cost is determined by the sum of the online selling price and the cost of connecting to the nearest trading place.

2.3 Interconnection Quality

Commoditization of Internet transit, facilitated by the emergence of a transparent trading place, usually provides higher incentives towards product differentiation. This shows, in particular, with the efforts to improve quality and reliability of the connectivity supplied. Quality depends on many aspects of a network like its capacity, architecture and the number of peering, private and public, agreements. There are, however, some simple ways of testing the quality of a connection and build quality indexes. In particular Band-X provides a quality index of the IP connectivity based on the network statistics described below. " The monitoring metrics used are: -*Traceroute* which measures the number of hops (or routers) which traffic passes through to get to a destination and back. This figure should ideally be as small as possible.- *Ping* is used to provide packet loss information, which indicates how much traffic is being lost, usually an indication of congestion or problems occurring on the network. This should be zero in a network performing properly. This metric also delivers the *round trip time* in milliseconds for the traffic to travel to and from a remote site. Again, the shorter the time, the better. -*Throughput* - the rate at which information travels across the IP network, is measured by examining the transfer rate for replies to HTTP requests for information on specific websites."[Source www. Band-X.com]

2.4 The European backbone market

In December 1999 the European Commission's eEurope[14] plan defined its three main objectives, of obtaining a cheaper, faster and secure Internet and identified the unbundled access to the local loop as a short term priority to bring about a substantial reduction in the costs of using the Internet. However high speed open access to the local loop is not sufficient to achieve, per se, the eEurope objectives. Indeed one of the main problems in securing a fast and cheap Internet access arises, not in the final connections between users and ISPs, but in the costs and quality of the connection between ISPs and the rest of the Internet. This issue has emerged in the drafting of the recent EU Directive on Access and Interconnection. In 1998 the association of European ISP's, EuroISPA (1998), pointed out that it was, in facts, common for many European ISPs to lease bandwidth to the United States to route intra-European traffic, as this was often commercially convenient[15] though technically inefficient.

In recent years there has, however, been a rapid transformation in the long distance telecommunication market: data traffic represents now more than 50% of the overall distance traffic and it is increasingly transmitted over the IP network. Entrants in the backbone market have deployed in the last years more than 10,000 route miles of fibre network and the amount of bandwidth which can be provided on a given strand of fibre is enormously increasing because of the new ways of exploiting fibre such as the dense wave division multiplexing (DWDM). An assessment of the impact of this investment wave on the competitiveness of the backbone market in the United Kingdom has been published by Oftel[16] . By using the test of the *hypothetical monopolist*[17] to design the vertical boundaries of the market Oftel came to the conclusion that Internet connectivity constitutes a market on his own. The definition of the geographic extension of the market for Internet connectivity identified three possibilities to buy connectivity for a British ISP : a) in the U.K., b) elsewhere in Europe or c) in the U.S. Oftel's enquiry found that the additional costs faced by a British ISP to buy connectivity outside the U.K. are high enough to make the U.K. Internet connectivity market competitive and therefore "self-contained" . This finding, conflicting with the earlier EuroISPA statements about the convenience of acquiring U.S.-based connectivity shows the effects of the recent evolution of the European backbone industry often described as fiber glut. In particular Oftel found over 20 suppliers of Internet connectivity, in the U.K. and failed to

[14]For account on this see Giovannetti, Kagami and Tsuji (2003).

[15]In 1998, for example, the monthly cost for a 2Mbps connection between London and Paris was of 38.000 $ while the same capacity connection between London and Virginia (the closest extra-European exchange point) was of 30.000$ even though Virginia is almost 25 times further away from London than Paris, Euroispa (1998).

[16]Effective competition review of Internet connectivity , Oftel (2001).

[17]From the Oftel document : " A product is considered to constitute a separate market if a hypothetical monopoly supplier could impose a small but significant, non-transitory price increase without losing sales to such a degree as to make this unprofitable. If such a price rise would be unprofitable, because consumers would switch to other products, or because suppliers of other products would begin to compete with the monopolist, then the market definition should be expanded to include the substitute products." Oftel 2001.

identify an operator as having a dominant position in terms of market volume. In its review[18], Oftel reached the conclusions that the wholesale IP transit market in the U.K. is effectively competitive and wholesale prices are falling. This conclusion, together with the OECD most recent study of the Backbone market, are, interestingly, conflicting with the results of the antitrust investigations on the WorldCom –Sprint proposed merger analysed in the Appendix.

Our analysis of the price and quality data from on-line bandwidth trading floors confirms the conclusion reached by Oftel and the OECD. For example, in Table 1 we present trading data for a typical 3 months contract for 10 Mbps of bandwidth in Band-X's London and New York trading floors, as recorded in the period 3 July to 5 November 2002.

[18] Oftel's review focussed on the intermediate level of Internet connectivity.

Table 1: Connectivity markets for typical 10 Mbps contracts in London and New York

		London		New York	
		Price (in £)	Quality Index	Price (in £)	Quality Index
EU	Average	1,331.3	118.8	1,482.1	19.2
	Var	27,932.8	756.2	14,3476.1	938.4
	st. dev.	167.1	27.5	378.8	30.6
	Best	1,080	144.1	799.0	24.0
US	Average	1,331.3	52.7	1,482.1	285.5
	Var	27,932.8	107.0	14,3476.1	25,959.9
	St. dev.	167.1	10.3	378.8	161.1
	Best	1,080	61.9	799.0	524.3

Source: Our calculations on data provided by X-band.

It is worth noting that connectivity at 10 Mbps is cheaper in London than in New York on average. Yet the best price can be found in New York. The quality index of connectivity (as calculated by Band-X) is substantially better in London for connectivity with the EU. For connectivity with the US New York maintains considerable advantage with an average quality index that is more than four times that for London.

The importance of the actual physical location of the ISP's connection to a backbone is on the whole confirmed. When quality is considered London proves far better for European connectivity at 10Mbps, while New York is the best market for US connectivity. On the whole these results would seem to indicate a marked change from the situation of the second half of the 1990s when a European ISP was often better off by buying bandwidth in the US even if its main interest was in connectivity with the EU. These results seem to confirm that the European market is currently characterised by a relatively larger supply of physical capacity at least at the 10Mbps level.

Bandwidth markets seem strongly influenced by physical and geographical factors. ISPs with a definite interest in regional connectivity (i.e. in connectivity either to the US or to Europe), are better served by the bandwidth-trading floor closer to the prevalent destination of their communication needs.

Admittedly, these are preliminary results based on a single bandwidth. And yet, given that quality indexes are not band-sensitive and that there is a seemingly linear relations between prices and bandwidth size, they are likely to be representative of behaviour of these transit markets.

Yet we would like to convey a word of caution on the robustness of these results. In particular the reader should be aware that on-line bandwidth trading is still in its infancy and therefore the prices and quality indexes here presented might be unrepresentative of the entire transit market. Yet, we think that they are valuable in two respects. Firstly, they provide what could be defined as an informed guess on the geographical stratification of backbone market that confirms the current prevailing view. Secondly, they provide an example of the richness of information that can be gathered from on-line sources on the structure and functioning of the Internet backbone capacity market.

3 Panel data Regressions

The data provided by Band-X contains prices by gross-connectivity supplier, location of the physical connection (London or New York), capacity band (1Mb per sec. 100), and contract length (1 month, 3 months, etc.). The site provides also indexes of the qualitative performance of the various suppliers. These indexes are: Round Trip Time in microseconds, the Packet loss in percentage, Transfer rate (in kbytes/sec); the number of Hops necessary a number of customary destinations; and a summary index of all the previous ones calculated by Band-X Quality index. All qualitative indexes are specific to each company. On the other hand, for technical reasons they are invariant across bands. The quality indexes are provided as moving averages of the performance of a particular supplier over a fixed period (typically 6 months, 3 months, 1 month, 2 weeks), or as daily observations.

We observed all this variables (prices by band, supplier, contract length, and location; moving averages of quality indexes by supplier, and destination of traffic, and daily observations of quality indexes by supplier, and destination of traffic) on a daily basis for the entire period from 3 July to 5 November 2002. Being unable to ascertain the methodology used by Band-X to collate this index, we were unwilling to use it. Moreover, its strong collinearity with the other quality indexes suggested that it is simply a weighted average of the other quality indicators. As such it is unable to convey additional information. For all these reasons we decided not to use it.

We also decided not to use the moving average versions of the quality indexes as they are improperly calculated, and wrongly report the effect of missing observations, and, more worryingly, of temporary technical breakdowns. The band invariance of the other quality indexes prevents us from implementing a fully-fledged hedonic regression. Yet the rich nature of the information by supplier puts us in an ideal position to perform a panel data analysis of these connectivity markets in New York and London. The next set of tables show the regression results for London and New York for IP Transit on 10Mbits band, three months commitment contracts, and 24 hrs. performance indexes.

We used a panel data model including individual effects for the results shown below. We assumed a fixed effects model specified as follows. For each firm i in the market:

$$\mathbf{p}_i = \alpha_i \mathbf{i} + \mathbf{X}_i \boldsymbol{\beta} + \varepsilon_i \qquad i = 1, ..., N$$

where

$$\begin{aligned} & \mathbf{p}_i \text{ is a } T \times 1 \text{ vector of daily prices for firm } i \\ \mathbf{i}_t \quad = \quad & (1, 1, ..., 1) \text{ is a } T \times 1 \text{ vector} \\ & \mathbf{X}_i \text{ is a } T \times K \text{ vector of daily observations on quality indicators} \\ & \boldsymbol{\beta} \text{ is a } K \times 1 \text{ vector of coefficients} \\ & \varepsilon_i \text{ is a } T \times 1 \text{ vector of errors} \end{aligned}$$

Where α_i are non stochastic time invariant unknown firm-specific coefficients. Stacking over the N firms in each market gives:

$$\begin{bmatrix} \mathbf{Y}_1 \\ \mathbf{Y}_2 \\ \vdots \\ \mathbf{Y}_N \end{bmatrix}_{(TN\times 1)} = \begin{bmatrix} \mathbf{i} & 0 & .... & 0 \\ 0 & \mathbf{i} & ... & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & ... & \mathbf{i} \end{bmatrix}_{(TN\times N)} \begin{bmatrix} \boldsymbol{\alpha}_1 \\ \boldsymbol{\alpha}_2 \\ \vdots \\ \boldsymbol{\alpha}_N \end{bmatrix}_{(N\times 1)} + \\ + \begin{bmatrix} \mathbf{X}_1 \\ \mathbf{X}_2 \\ \vdots \\ \mathbf{X}_N \end{bmatrix}_{(TN\times K)} \boldsymbol{\beta}_{(K\times 1)} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_N \end{bmatrix}_{(TN\times 1)}$$

The Model is then estimated using OLS on the deviations from the market mean and the estimation includes only companies that traded for the entire period. Given the absence of a-priori choices for the quality indicators, we opted for an exclusion methodology, aimed at minimising collinearity and maximasing the model fit. The final regressions are presented below.

London

Model Summary[b]

	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
	.981[a]	.963	.963	2.296E-02	.963	2254.540	12	1034	.000	.183

a. Predictors: (Constant), L, J, H, I, F, RTTEU, E, A, B, K, C, D

b. Dependent Variable: PRICE

where letters are the company dummies, and RTTEU stands for Round Trip Time to Europe (in ms.).

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Stand. Coef. Beta	t	Sig.	95% Confidence Interval for B Lower Bound	Upper Bound	Correlations Zero-order	Partial	Part	Collinearity Statistics Tol.	VIF
1	(Cons)	.171	.003		64.796	.000	.166	.176					
	RTTEU	4.426E-02	.008	.074	5.414	.000	.028	.060	-.331	.166	.032	.188	5.32
	A	-.350	.004	-.816	-98.946	.000	-.357	-.343	-.456	-.951	-.590	.523	1.91
	B	-.272	.004	-.635	-69.464	.000	-.280	-.265	-.243	-.907	-.414	.426	2.35
	C	-.253	.003	-.591	-72.999	.000	-.260	-.247	-.224	-.915	-.436	.543	1.84
	D	-.284	.006	-.663	-43.986	.000	-.297	-.272	-.224	-.807	-.262	.157	6.39
	E	-.260	.004	-.606	-72.398	.000	-.267	-.253	-.224	-.914	-.432	.507	1.97
	F	-.251	.004	-.586	-71.055	.000	-.258	-.244	-.205	-.911	-.424	.524	1.91
	H	-.148	.004	-.342	-41.241	.000	-.155	-.141	.059	-.789	-.246	.518	1.93
	I	-.109	.004	-.254	-30.001	.000	-.116	-.102	.163	-.682	-.179	.498	2.01
	J	-.108	.004	-.242	-29.720	.000	-.115	-.100	.154	-.679	-.177	.538	1.86
	K	4.944E-02	.003	.115	14.279	.000	.043	.056	.549	.406	.085	.545	1.83
	L	-7.48E-02	.003	-.175	-21.612	.000	-.082	-.068	.233	-.558	-.129	.545	1.83

a. Dependent Variable: PRICE

New York

Model Summary[b]

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
.999[a]	.998	.998	.0140345	.998	25664.935	5	310	.000	.172

a. Predictors: (Constant), P, HEU, N, O, PLEU

b. Dependent Variable: PRICE

where letters are the company dummies, and HEU stands for the number of hops to Europe and PLEU stands for the percentage Packet Loss to Europe.

Coefficients[a]

		Unstandardized Coefficients		Stand. Coef.			95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tol.	VIF
1	(Cons)	.338	.002		159.569	.000	.334	.342					
	PLEU	8.E-03	.004	.010	2.281	.023	.001	.016	.510	.128	.006	.377	2.655
	HEU	-.018	.007	-.009	-2.573	.011	-.032	-.004	.090	-.145	-.007	.693	1.443
	N	-.782	.003	-1.196	-259.931	.000	-.788	-.776	-.895	-.998	-.725	.367	2.725
	O	-.333	.003	-.509	-118.177	.000	-.338	-.327	.025	-.989	-.329	.419	2.386
	P	-.264	.003	-.403	-85.397	.000	-.270	-.258	.162	-.979	-.238	.349	2.868

a. Dependent Variable: PRICE

Our results are not surprising given that the low variance of price and given that most of it is between companies. For example this explain the otherwise worrying high fit of the models. The little price variance that there is, is mostly explained by the companies' dummies as shown by their high coefficients and the fact that these coefficients are statistically very significative). This indicates that the markets are not competitive, and that brand effects play a major role. Price variations are only marginally affected by qualitative dimensions (low coefficients, and on the whole less statistically significant). This is confirmed by the fact that the Adj. RSq. is very high even omitting entirely these variables. The relative unimportance of qualitative indicators confirms the non-competitive nature of these markets. Moreover, for technical reasons the quality indexes tend to move in synchrony, and therefore are responsible for the most of the collinearity present in the initial regressions. The fact that only a few of them are statistically significative in the final regressions shows that most of the information that each of this index conveys is redundant. Finally the sign of the coefficient is not necessarily the 'right' one. This suggests that the market is even less perfect than the high significance of the dummies might suggest, as companies with high prices are often able to supply an inferior service. Moreover, it indicates that market dominance is not achieved through a better set of peering agreements as they should improve the quality of the service.

4 Conclusions.

Different analysis of the Internet backbone market provide different answers about its degree of concentration. This variability is mainly due to the paucity of existing data as opposed to that required to design the vertical and horizontal borders of the relevant market, and different market definitions provide opposite antitrust prescriptions.

We used online transit prices to monitor indirectly the evolution of the market, by-passing, in this way, the difficulties of mapping the borders and hierarchies in the Internet backbone structure. Many of the relevant questions have been addressed by using the available information on online prices and quality. This data indicates a changing structure of the Internet Connectivity Map, showing the emergence of a less hierarchical and multiheaded backbone structure with separate U.S. and European transit markets. However this process seems to have left elements of market power, which may be specific to the role reputation still plays in the infancy of online trading markets

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5 Appendix .The proposed merger between MCI/ WorldCom and Sprint

The two most relevant antitrust cases discussed in the industry have been the merger between MCI and WorldCom in 1998 and the rejected merger between MCI-WorldCom and Sprint in 2000. After an extensive investigation into the merger proposal, on the 28th of June 2000 the European Commission adopted the decision that " The notified concentration consisting of the merger between MCI-WorldCom and Sprint is declared incompatible with the common market and the functioning of the EEA Agreement." [Official Journal of the European Commission (2000)]. Similarly on the 26th of June 2000 the U.S. Department of Justice stated " The proposed merger of WorldCom and Sprint will cause significant harm to competition in many of the nation's most important telecommunications markets. By combining two of the largest telecommunications firms in these markets, the proposed acquisition would substantially lessen competition in violation of Section 7 of the Clayton Act ..The merger would lead to higher prices, lower service quality, and less innovation than would be the case absent its consummation. The United States therefore seeks an order permanently enjoining the merger". [U.S. DoJ 2000 page 3]

The dominant position of WorldCom has indeed been attained through a very active acquisition policy. The DoJ enquiry describes some of the more than 60 acquisitions operated by this company: for example in 1995 WorldCom acquired the network service operations of Williams Telecommunications, with its 11,000 mile fiber optic network, in 1996, through the acquisition of MFS Communications Company, WorldCom obtained the control of UUNET, the world largest Internet backbone provider. In 1998 WorldCom acquired Compuserve a leading Internet provider and ANS, AOL's primary Internet backbones network. Other acquired backbones were GridNet, Unicom-Pipex, InNet, NL Net and Metrix Interlink. As a result of the leadership position reached in these years the WorldCom acquisition of MCI in September 1998 has been accompanied by the imposition, by the US DoJ and the EU Commission, for MCI to divest its Internet assets to Cable & Wireless.

The major source of disagreement between the Commission and the two defendant companies, concerned the hierarchical nature of the Internet. The Commission stressed that a hierarchical structure was clearly exposed by the evidence that top level providers achieve their connectivity entirely by settlement-free peering mainly at private peering points, whereas smaller providers need to purchase transit from top-tier network to achieve global connectivity. If connectivity is crucial in defining market leadership the physical expression of market shares is given by traffic flows. The ratio between traffic flows of the different networks have therefore been used to evaluate market shares as reported in Table A1, below, together, for reference, with a revenue based market share distribution obtained by Probe Research (Pappalardo 2001)

Top tier backbones	MarketShares (revenuesper year 2000) Source probe Research[20]	MarketShares (traffic ratios) Source EU
GTE	6.3%	$[0-10]\%$
Sprint	6.5%	$[5-15]\%$
C&W	3.5%	$[0-10]\%$
MCIWorldCom	27.9%	$[32-36]\%$

Top tier backbones Market Shares (Revenues year 2000)

From these estimates the new merged entity would have had a market share between [37-51]% against the next competitor's one not being larger than 15%. The European Commission concluded that the proposed merger would have led to the emergence of a top level network provider, able to act almost independently of its competitors and customers and to determine its own, and its competitors, prices and the technical developments in the industry.

The U.S. Department of Justice enquiry provides an alternative estimate of the Tier 1 market shares and the effects of the merger: "The Herfindahl-Hirschman Index ("HHI"), ... indicates that this market is highly concentrated. The HHI in terms of traffic is approximately 1850; post-merger, the HHI will rise approximately 1150 points to approximately 3000. The proposed merger threatens to destroy the competitive environment that has created a vibrant, innovative Internet by forming an entity that is larger than all other IBPs combined, and thereby has an overwhelmingly disproportionate size advantage over any other IBP."

Finally concerning the issue of the threat of quality degradation the European inquiry estimated that the traffic remaining on net for the newly merged company will be between 40 and 80 percent compared to a percentage of no more than 32% for the other connectivity providers. These would then be forced to exchange around 20% of their traffic with the new dominant player and this size asymmetries would imply that a degradation of the quality interface will have a worse effect on the smaller size networks than on the larger one .

Quality issues have been considered in both the European and American enquiries also from a dynamic prospective in relation to both market tipping and potential entry in the industry. Since the existing free-peering rules require an entrant, or existing partners, to be of considerable size the enquiries found that the merger would have generated both an endogenous market tipping process in

[22] See Pappalardo, D. "The ISP top dogs" Network World Fusion , 30 May 2001.

favour of the dominant backbone together with a formidable barrier for potential entrants in the top tier backbone market.