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Assessing The Impact Of Internet Telephony On The Deployment Of Telecommunications Infrastructure

by

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Abstract

The purpose of this research is to determine whether Internet telephony has had a negative impact on a country's telecommunications infrastructure. Using panel data the statistical analysis shows that call-back did not have a negative effect on infrastructure and high income countries benefited from that technology. Internet telephony shows a negative impact in high and lower middle income countries but at such a small scale that governments should not be concerned. Additionally the year variables show that for all income levels infrastructure has increased which means that if this technology will show any negative effects it will be in a gradual manner and should give carriers enough time to adjust their practices.

Keywords: Regulation, Internet telephony, call-back, infrastructure, teledensity

JEL Clasification: O14, O33, O38

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Assessing the impact of Internet telephony on the deployment of telecommunications infrastructure

1. Introduction

The purpose of this paper is to show the impact of Internet telephony on telecommunications infrastructure. It is based on an empirical investigation of panel data with approximately 180 nations over a period of four years. The focus is on Internet telephony because there are governments that have banned the provision of these services. There is some justification for their concerns and this is related to the low level of telecommunications infrastructure that they currently have. While in developed countries on average there are 50 phone lines per 100 inhabitants, the average in developing countries is 10 (ITU, 2002). Infrastructure in developing countries thus lags substantially behind that of the developed world and requires further development to foster economic activity. In the absence of basic and affordable services, the emergence of the Internet has allowed people without access to household or mobile phones to make international calls at prices 30% to 50% cheaper through Internet cafés. Regulators in countries with low levels of infrastructure are concerned that permitting Internet telephony will destroy the telecommunications operators' incentive for infrastructure investment. This is because in many less developed countries (LDCs) a large percentage of revenue is still generated from incoming and outgoing international calls, which subsidize local services. In the presence of such competition there is a fear that the carrier will not be able to cover its investment in the network and will thus have no desire to expand it.

There are, nonetheless, studies (Lam, 1997; Frieden, 1998) that have argued that voice over the Internet (VOI) does not affect infrastructure because previous technologies such as call-back and international resale as well as political pressure from the United States and the World Trade Organization (WTO) have already reduced revenues from international traffic close to real costs. If this is the case, why are there still so many nations that prohibit the use of VOI?

Governments of developed countries decided in the late 1990s to allow the provision of VOI services. They may need to revise these decisions because the technology has evolved to offer quality comparable to that of traditional carriers. The U.S. is currently reviewing this issue because VOI carriers do not have to pay international settlement or local access charges or contribute to universal service funds that traditional carriers do. At the same time the technology is becoming more prevalent and quality has significantly improved.

Because there are many factors that affect infrastructure investment, the empirical model takes into consideration factors such as privatization of the incumbent carrier, level of competition, outgoing international telecommunications traffic, price of international calls, and control variables such as population density and income per capita.

This research is aimed at providing policy guidelines. It is timely and relevant because it will help regulators concerned about the regulatory implications of this technology for the expansion of telecommunications infrastructure. This research will also contribute to the academic literature on creative destruction. New technologies have the potential of displacing outdated ones and thus bringing with them numerous benefits.

2. Understanding the problem

The use of the Internet to make telephone calls originated in 1994 with computer enthusiasts who, using special software, were able to send voice messages (Kelly et al., 2001). The technology rapidly attracted attention more for its innovativeness than for its practical use. In developing countries it seemed to be more a curiosity than a real threat to the established traditional telecommunications operators. Internet telephony is a progression from the technologies that form the Internet. At first, making calls with computers required special software, a microphone, and a headset. VOI service providers now generally offer the software free of charge. As well, microphones are often integrated in laptop computers and basic headphones can be used without having echo interference from voices when both parties talk simultaneously.

In nearly ten years since the technology first emerged important developments have taken place. Internet telephony has been adopted differently in developed and less developed countries. In the developed world personal computers are hardly ever used to make phone calls. Young people and international students have used them to save money when calling family and friends. For the most part, the technology has aimed to optimize the traditional circuit switched networks that made an inefficient use of the infrastructure by having only two people use an entire line. Using IP packets, bandwidth is released for additional voice conversations and data services can also be added.

In LDCs there have been limited efforts to upgrade infrastructure to use IP technology. Instead companies providing Internet telephony have perfected their systems to allow people to use the public Internet to make telephone calls. Equipment has been developed to add cards to computers so that telephone sets can be connected to make the calling experience more natural and similar to the experience of using traditional switching technology.

Companies such as Net2Phone and Vocaltech have developed sophisticated packages aimed at Internet cafés, public calling centers, calling card providers, hotels, and marketing centers among other businesses. The solutions are intended to generate revenue for both the VOI facilitator and these organizations. For Internet cafés, for example, the marketing promotion of Net2Phone highlights the ability of the new equipment to generate additional revenue for the establishment because users who want to make calls no longer need to be tied to the computer. They can use the handset and then allow other users to browse the Internet while the call is taking place. The café can thus obtain revenue from two sources at the same time, effectively multiplying the use of a computer and connection to the Internet.

Companies that offer these services advertise 90% to 95% discounts from the retail cost of a call through the traditional telecommunications carrier. Table 1 lists the prices for Net2Phone and traditional communications from a random sample of countries.

Table 1
Price comparison of a 3 minute call to the U.S. ($US)

Country	Traditional 2001*	Extrapolated 2003**	Internet 2003	Percentage difference
Hong Kong, China	2.6	2.62	0.117	2,235
Laos P.D.R.	6.3	5.44	0.147	4,330
Azerbaijan	7.8	7.4	0.147	4,733
Niger	10.4	10.4	0.147	5,963
Mali	14.6	14.6	0.147	8,352
Paraguay	1.08	0.72	0.15	549
Portugal	1.02	1.02	0.15	576
Hungary	1.18	1.63	0.147	668
Belize	2.83	2.83	0.15	1,890
Jordan	2.67	0.46	0.147	1,820

Source: ITU World Telecommunications Development Indicators and Net2Phone
*Latest year available ** Calculated from previous years

With the release of bandwidth that is possible with this technology companies are able to offer competitive rates.

2.1. The market

In analyzing the effects of Internet Telephony on the deployment of telecommunications infrastructure one needs to consider countries where ICT infrastructure is limited. In developed countries, where teledensity is greater than 50 lines per 100 inhabitants, there is little concern and incumbents do not consider it a threat. In these markets communication access is almost universal and rates are relatively low. Similarly the quality of the service provided through Internet telephony has been low enough that the price difference does not justify the inconvenience.

In developing countries with limited infrastructure the situation is quite the reverse. There are places where people have to wait for several years before they can obtain a telephone line. In low income countries the average waiting time is 1.5 years with some countries like Kenya or Ukraine where people wait 8.1 and 7.4 years respectively (ITU World Telecommunications Indicators, 2002). It is thus not surprising that the Pakistani government made Internet telephony illegal, enforcing this through restrictive contracts that explicitly prohibit companies from providing the service.

In LDCs we encounter two types of problems. One is that phone lines are widely available but income is so low that few can afford them. In many countries the problem is not obtaining a line but rather the funds people have to keep it. In these countries the problem is not the lack of infrastructure but poverty.

Another situation is where the infrastructure does not exist and people want access to these services. Of the 211 countries that are listed in the ITU's World Telecommunications Indicators, 103 have waiting lists. The longest list was that of Russia with more than 6 million people waiting for a line, followed by Syria, India, and Ukraine, which had between two and three million people waiting in 2000. Countries with waiting lists also tend to be poor, as 37% of those are in the low or low middle income category. When people are unable to obtain a phone line and

rates to call abroad are artificially high there is a strong incentive for them to try inexpensive alternatives. In the mid 1980s individuals filled this need by setting up clandestine operations that allowed people to make illegal telephone calls at a lower expense. Soon afterward call-back services became popular even though many nations prohibited them. Internet telephony is thus another alternative where, in spite of the inconvenience and lower quality, people are willing to use it. The alternatives are either not available or not affordable. This is why the technology has become much more popular in LDCs than in developed countries.

2.2. Incentives for carriers

It is not only the governments of some countries that have prohibited the use of the public Internet for voice. Communication carriers themselves may have justifiable incentives to prohibit its use. The technology can affect these carriers' revenues significantly. While in the 1950s international telephone services amounted to only 20% of a carrier's revenue, in 2000 this corresponded to 95% (Sharifi, 2001, p. 315). International incoming and outgoing telephone traffic is highly profitable, particularly in countries where artificially high accounting and settlement rates lead to substantial hard currency remittances from foreign carriers.

Revenue from data is lower. ISP carriers that lease the infrastructure are not obliged to pay per minute charges to the carrier for interconnection. They also do not have to pay settlement rates for international traffic, as recommended by the World Trade Organization. This means that an ISP providing this type of service can generate additional revenue from voice traffic without having to pay extra to the carrier that leases the infrastructure to it. For people who have Internet access at home they can place international calls through their dial-up connection to the Internet paying only for a local call and the much lower rate that Internet telephony carriers charge, for which the telephone company does not obtain any additional revenue. In most countries ISPs are not obligated to contribute to universal service initiatives. This means that Internet telephony may have a negative effect on traditional carriers' revenue.

The scenario is different in developed than in developing countries. When VOI first emerged, governments had to decide if they would allow it or not. If they

were to do so they would need to determine if they could regulate it. In developed countries regulators considered that VOI had such primitive features that it could not considered voice telephony (McKnight and Leida, 2001, p. 213) and that it posed no threat to current carriers. In spite of these assertions there was concern among some observers about the technology. In the United States some members of Congress felt that diversion of traffic to the Internet and lack of contribution from ISPs could endanger universal service (Weinberg, 2001, p. 336). Some Federal Communications Commission (FCC) officials recognized that the exemption could create an incentive to shift traffic to IP networks (Weinberg, 2001, p. 338). When the technology first appeared a group of operators created an association called ACTA to lobby the government for the regulation of Internet telephony. In spite of ACTA pressure, the FCC decided not to intervene. In Canada the concern was about contributions for the continued investment in communication networks. At the time the government decided not to require contributions from ISPs but left the door open for future consideration.

In the European Union, the European Commission's Directorate General for Competition provided a series of guidelines to determine if Internet telephony should be regulated or not. The decision was to not regulate it. The main factor in the set of guidelines was the specification regarding quality. For a service to be regarded as voice telephony it had to be real time. As Internet telephony at that time experienced substantial delay, it did not meet this criterion. In Japan the provision of these services was allowed but required approval of the Ministry of Post and Telecommunication (MPT).

In spite of their initial opposition, carriers in developed countries determined that the technology had benefits and they adopted IP protocols in their traditional networks. The objective has been to optimize the use of these lines.

In LDCs the situation is different. Lack of lines has made voice over the Internet quite attractive. In Tegucigalpa an Internet café in the main mall is even considered a tourist attraction because of the number of people who are waiting in line to make an Internet call in spite of the fact that the service is prohibited. Another factor contributing to the wider use of this technology are the much higher prices for

international calls that still exist in many of these countries. The more extensive use of Internet telephony together with the reduced revenue that traditional carriers are able to obtain from this service have prompted many carriers to adopt measures that block this activity. Some have lobbied governments to regulate or prohibit Internet telephony. Monopoly carriers are unwilling to negotiate agreements with ISPs that provide Internet telephony and they can also blocks ports that are used to route voice traffic.

One could argue that it is foolish of these organizations to oppose the provision of these services considering that voice traffic is growing at a considerably slower rate than data traffic. Carriers in these countries do not see it this way because they do not experience much data traffic yet and would like to delay for as long as possible the reduction in their revenues resulting from lower voice traffic. Additionally, the existing revenues of carriers are insufficient to upgrade their obsolete and limited infrastructure. These companies require not only the revenues that they may be obtaining from artificially high rates but also direct support from governments, if they are still state owned, to provide more advanced communication services to the population. These carriers, unlike their developed world counterparts, do not have the resources to upgrade their infrastructure to install equipment that can take advantage of IP technologies. These countries see Internet telephony as a direct competitor and threat. We will explore below if the fears of these carriers and governments are justified.

2.3 Why prohibit Internet telephony?

The previous section described the reasons why carriers in LDCs would not like ISPs to offer Internet telephony. There are also legal constraints. A government, for example, might want a new technology to compete directly with the incumbent carrier as a way of introducing competition to the market and to motivate the traditional operator to upgrade its network. The problem is that many of these governments made concession agreements during the privatization process under which they promised companies a certain number of exclusive services to make the offer more attractive. They thus were able to sell the operator but are now unable to allow voice telephony through the Internet because this would violate the agreement

with the privatized operator. There are other countries, such as Costa Rica, that have constitutional limitations to opening markets for Internet telephony.

3. Previous research contributions

The main concern over the impact of Internet telephony is with the potentially negative impact that the technology can have on operators' revenues, which are derived primarily from international traffic. This section reviews previous research that has analyzed the impact that technologies and political pressure from abroad have on international revenues.

3.1. The impact of information technologies on international revenues

Internet telephony is not the first technology that has posed a threat to revenue for carriers. There have been others such as call-back and international resale that were expected by many to negatively affect flows of capital for a country's investment in infrastructure.

Scholars have argued that call-back, international resale, and whipsawing[2] have put pressure on accounting rates. They expect that arbitrage opportunities would thus disappear (Lam, 1997; Frieden, 1998; Clark, 2001). One could thus expect that these services would have already reduced accounting rates to the point that Internet telephony should thus have no impact. This means that if there were a negative impact on infrastructure it would have happened in the early 1990s when call-back services were entering international telecommunication markets. Similarly, statistics from the FCC about international payments to foreign carriers indicate that settlement payments have been reduced from 1995 to 2001 by more than two thirds.[3]

3.2. The impact of international pressure

In 1997 there was also pressure from both the United States and the WTO to reduce accounting rates. The U.S. was concerned about the large payments that its

2 This allows a person in Zimbabwe, for example, to make an international phone call to South Africa, but make it seem like the call originated in the U.S.

3 Statistics of Communications Common Carriers, FCC, http://www.fcc.gov/Bureaus/Common_Carrier/Reports/FCC-State_Link/socc.html, accessed May 4, 2003.

national operators were making to foreign carriers, thus leading to a large trade imbalance. This prompted the FCC to develop a series of benchmarks regarding the maximum amounts that U.S. carriers were allowed to pay foreign operators. At that time there was strong criticism on the part of foreign governments who complained to the U.S. on two grounds: that there was a lack of U.S. jurisdiction, and that such measures could severely cripple investment in infrastructure in poor countries. The FCC argued that they have the right to determine rates for their carriers under both domestic and international law (Cowhey, 1998, p. 905). Aware of the potential impact on investment, the FCC set its benchmarks for LDCs at a higher level and they were also given a longer time to comply (Cowhey, 1998, p. 906). The International Bureau of the FCC conducted a study to determine the impact of international settlement and network build out. It concluded that there was not a statistically significant relationship (Cowhey, 1998, p. 907). The imposition of benchmarks by the U.S. in 1997 should also have negatively affected foreign carrier revenues and thus investment in infrastructure.

Pressure also came from the WTO where, in 1997, 69 countries developed guidelines for the liberalization of telecommunications markets. Among the series of commitments was the introduction of competition during a specified period. These measures were thus expected to reduce the trade imbalances that were generated by monopolized markets and artificially high international accounting rates.

Of the studies reviewed on this subject only the FCC study mentioned by Cowhey (1998) provided empirical evidence. We thus cannot assert with certainty that these services indeed reduced international accounting rates and thus revenues for LDC carriers.

3.3. The impact of the Internet on information infrastructure

In spite of the work from scholars that theorized that call-back, resale, and international pressure would result in lower revenues for foreign carriers, there was considerable debate about the impact of Internet telephony when the technology first emerged in 1994 (ITU, 2001). Scholars that have written on the subject fall on both sides of the issue. Cawley (1997) predicted that Internet telephony does not lead to lower investment but instead motivates the upgrade and greater adoption of other

telecommunication technologies. Mason (1998) argued that Internet telephony should have no effects on accounting revenues because this technology is so inferior to alternative technologies that he finds it unlikely that people would prefer that medium over others that are more convenient and of higher quality than an Internet connection. He argues that phone based services such as call-back were better alternatives and that VOI would not have an impact on investment. Similarly the International Telecommunications Union (ITU) in its report about Internet Telephony (2001) concluded that other technologies have already put substantial pressure on the revenues that operators could generate. The authors did not believe that VOI alone could have a great impact on investment either.

In the United States carriers were concerned about a decline in their revenues. The ACTA association of carriers argued that this would lead to increased traffic on a network that was only designed to carry short voice conversations. In their lobbying efforts they stated that the upgrade of their networks to carry this amount of traffic would cost them millions of dollars (Moore, 1997). They wanted to be compensated in the form of access charges. Some scholars believe that Internet telephony threatens the viability of the international accounting system (McGarty and McKnight, 2001).

We now know that in the U.S. the growth of the Internet led to greater investment in telecommunications and increased revenues. While this success story has been repeated in other developed countries this has not been the case in less developed ones. There are several factors that inhibit progress in LDCs: (1) lack of infrastructure to carry even basic voice; (2) low personal income, which limits the amount that households spend on communication services; and (3) obsolete communications equipment. It is thus in LDCs where Internet telephony could potentially have a negative impact on telecommunications investment. Previous technologies such as call-back may have already had a negative impact.

Although none of the studies reviewed provide empirical evidence, the general consensus appears to be that Internet telephony would not have an effect on telecommunications infrastructure. In spite of this belief, there are approximately 40 countries that have reported that they prohibit VOI. Most countries that forbid VOI

have either state monopolies or privatized enterprises with continued state participation. Only five of the countries that prohibit VOI have a privatized telecommunications carrier. Why is this? If revenues are already low as a result of the implementation of other technologies as well as international pressure, governments should not be as concerned about the impact of VOI. The purpose of this research is to determine if these concerns have merit by testing empirically if Internet telephony is inhibiting infrastructure deployment. As the technology has improved substantially, some now believe that regulation is necessary. Kiser and Collins (2003) argue that Internet telephony is now a technology that is more widely used and, in spite of this it still faces no regulatory burden. Operators providing Internet telephony are not obliged to pay settlement charges for international voice communication and they do not contribute to universal service funds. They thus suspected that regulators around the world would revisit this issue given that they perceive the advantage of these carriers as unfair.

4. Hypothesis development

The metric that is used in this study to measure telecommunications infrastructure is total number of telephone lines per 100 inhabitants, which includes both wired and wireless lines.

Multiple factors affect the deployment of a telecommunications infrastructure and these must be considered in addition to Internet telephony.

Scholars have identified factors within several categories. Table 1 shows those that have been presented by authors of other studies and how they were operationalized in this study. The table is divided in three categories. Their origin is from Bernt and Weiss (1993) who identified four categories: regulatory, organizational, economic, and technical. A more recent study by Mbarika et al. (2002) added four more categories: financial, managerial, political, and geographical. Table 2 includes only those categories and variables for which data is available for the period from 1999 to 2002.

Table 2
Included Variables

SOURCE	FACTOR	VARIABLE
Economic		
Mbarika (1999)	GDP	GDP per capita (1995 $U.S.)
Yatrakis (1992)	Volume of trade	Trade a as percentage of GDP
CCITT (1965,1995) as reported by Mbarika Mbarika (1999)	Tertiary sectors	% employment in agriculture % employment in manufacturing % employment in services
ITU (1994)	Inadequate private sector involvement	Level of Competition (Local, Int'l and ISPs) 1=monopoly 2=duopoly 3=partial competition 4=full competition
Maitland Commission (1984) Wellenius (1989) ITU (1994)	Foreign capital	Financing from abroad % GDP
Organizational		
Wellenius (1989) ITU (1994) Ramamurti (1996) Ros (1999)	Autonomy from government/Privatization	Dummies 1=state owned, 2= semi-privatized, 3=privatized
Regulatory/Policy/Political		
ITU (1994)	Lack of a Universal Service Policy	Dummies: Universal Service Policy 1=Yes
Kirunda-Kkivenjinja (1995)	Roads, Sewage, Water	Roads (network size in km)
ITU (2001) Bernard (1994) Lam (1997) Frieden (1998) Clark 2001).	Call-back, international resale, and whipsawing	Dummy: Call-back allowed by the government 1=yes
	Internet Telephony	Dummy: Internet telephony allowed by government 1=yes

Based on the research that other scholars have done on Internet telephony, we know that there is still disagreement with respect to the effect of voice on the Internet on the further development of the telecommunications infrastructure. Scholars tend to believe that this technology should have no effect on further investment in infrastructure but private sector officials as well as regulators in many countries believe the contrary.

This study developed hypotheses based on arguments made in the literature with respect to previous technology, international pressure, and economic factors. Scholars that have studied the effect of voice over the Internet believe that the call-back, international resale, and whipsawing effects that emerged in the late 1980s would have already reduced the revenues of carriers. Even though this is likely to be the case, there were countries that also banned call-back and whipsawing. One could

thus potentially argue that in those countries revenue may not have fallen as much as these scholars expected. These types of services may, however, have been so difficult to monitor and enforce that even with government opposition, they were provided, thus negatively affecting revenues of carriers. This study includes dummy variables for both call-back services and Internet telephony.

H1: After controlling for call-back, telecommunications infrastructure (teledensity) does not decrease as a result of Internet telephony.

As outlined above, there was domestic pressure to reduce settlement rates for international traffic. Unfortunately there is no publicly available data about these rates and thus it is not possible to evaluate the impact that international pressure had on the costs of transborder calls, the revenues of carriers, and infrastructure expansion or improvement.

There are, however, other more subtle international factors that can equally affect the prices of telecommunications services and a carriers' telecommunications revenue. These include the amount of trade activity, the level of employment in the service and manufacturing sectors, the amount of foreign capital that governments receive, as well as the amount in minutes of telecommunications traffic from other countries. The following hypothesis is based on assuming these factors as proxies for international pressure.

H2: After controlling for the sizes of the service sector, trade, foreign aid, and international traffic, the presence of Internet telephony has no impact on infrastructure.

The economic circumstances of a country can affect investment in telecommunication networks. There is a widely held belief that potentially low levels of demand in the poorest countries will mean that investment in these services is unprofitable. Under these circumstances many governments are unable to attract enough private sector capital. In Guatemala where a Universal Service fund was established, the organization responsible for the disbursement of subsidies was unable to attract any providers of services. Because this was a competitive process

no company was willing to do the market research and then fail to obtain the subsidy during the bidding process.

Lack of income influences both private and public sector decisions. Without this type of information investors will be unwilling to take risks. Taking into consideration that economic factors play a role in a company's willingness to invest we would expect:

H3: After controlling for the income level of the population, Internet telephony has no impact on the telecommunications infrastructure of a country.

5. Data analysis

This section examines the impact that technological, regulatory, and economic factors have on the deployment of telecommunications infrastructure. The first part presents descriptive statistics to help understand the general circumstances of the market, the carriers, and the regulatory restrictions that were put on these technologies. It will help identify the countries where call-back was available. It also identifies the market conditions of those countries with respect to the ownership status of the main telecommunications operator as well as the level of competition to determine if these factors were related to the decision to allow or prohibit the use of technologies such as call-back and Internet telephony. The second part presents a regression analysis of the variables of interest.

5.1 Descriptive statistics

Technologies are likely to have different effects on countries depending on level of income. Table 3 shows descriptive statistics for each of the factors included in the statistical analysis by level of income.

Table 3
Descriptive statistics: means

Variable	Low income	Medium low income	Medium high income	High income
Telecom revenue	58,016,035	166,575,630	566,881,021	1,557,223,088
GDP per capita	379	1,409	4,782	19,437
Trade	68	90	93	105
Employment in services	46	54	55	63
Employment in agriculture	43	26	15	5
Employment in industry	16	22	26	27
Financing from abroad	2.8	2.2	2.0	1.9
International incoming telephone traffic	28,234,918	75,575,295	142,508,186	338,407,044
Cost of 3 min call to USA	4.45	5.3	3.82	5.44
Population	9,480,238	4,143,411	4,095,379	2,995,644
Number of countries	61	50	33	43

We can see from this table that higher income economies also have higher levels of trade, greater levels of service and industry workforce, and a smaller agricultural sector. There is more traffic flowing into higher income countries and a call to the U.S. is cheaper as income increases.

Scholars have argued that technologies such as call-back, which came before Internet telephony, had a negative impact on the revenues of the telecommunications operators. In 1999 and 2000 the ITU asked telecommunications regulators if they allowed or prohibited call-back services. This information is summarized in Tables 5 and 5. The majority of countries did not allow it. Call-back was less likely to affect the revenue of operators in places where it was not permitted. The large number of countries that did not allow call-back services in 2000 is surprising considering that carriers had many years to lower prices to meet this competition. It is also surprising because in 2000 many countries had already privatized and liberalized their telecommunications industry and thus imposing restrictions on these services would not reduce rates. Restrictions on call-back services and subsequently on Internet telephony may have been related to the terms of privatization that were granted to

the company. In many of these cases private operators were given several years of monopoly status. Tables 4 and 5 present the percentage of countries that prohibited call-back services and compares these based on the ownership of the incumbent and the level of competition. Table 4 shows that in those countries where the market is monopolized 69.5% of regulators did not allow call-back services while 67.4% of countries that experienced either full or partial competition permitted call-back services. Similarly in 54.3% of the countries that did not allow call-back, the telecommunications operator remained under state ownership while 84% of those countries that allowed the services where either privatized or partially privatized. This could be an indication of government concerns about having a decline in international revenues as a result of this service. It could also be an indication of the concession agreements that were done when privatization took place.

Tables 4 and 5
Percentage of countries that allow call-back services according to the ownership of the incumbent and level of local competition

	Call-back	
	Not allowed	Allowed
Monopoly	69.5	30.2
Duopoly	5.5	2.3
Partial competition	10.2	55.8
Competition	14.1	11.6

N = 172
Pearson chi2(4) = 40.5013 Pr = 0.000

	Call-back	
	Not allowed	Allowed
State owned	54.3	16.3
Privatized	5.4	32.6
Partially privatized	40.3	51.2

N = 171
Pearson chi2(2) = 30.7213 Pr = 0.000

Table 9 lists the countries that prohibit Internet telephony by income level. Countries of the European Union are not included in this table because of a directive that permits the service because it does not meet the standards of voice telephony.

Tables 6 and 7 present the percentage of countries that prohibited this service according to the level of competition and the ownership of the incumbent. The results are similar to those of call-back services. 78% of the countries that decided to prohibit Internet telephony also have monopolized markets and the carriers are state owned. In contrast, 73.5% of the countries that allowed these services also experience either full or partial competition. Similarly, 53% of countries where Internet telephony was banned still maintained a state carrier under state ownership

while of those countries where the service was allowed 73% had been privatized or partially privatized. In both cases the χ^2 is significant.

Tables 6 and 7
Percentage of countries that allow Internet telephony services according to the ownership of the incumbent and level of local competition

	Internet Telephony	
	Prohibited	Allowed
Monopoly	78.18	26.53
Competition	5.45	48.98
Partial competition	16.36	24.49

N = 104
Pearson chi2(2) = 32.5957 Pr = 0.000

	Internet Telephony	
	Prohibited	Allowed
State owned	52.73	26.53
Privatized	7.27	22.45
Partially privatized	40	51.02

N = 104
Pearson chi2(2) = 9.2380 Pr = 0.010

Table 9
Countries that prohibited Internet telephony services by income level (2000)

Low income countries	Lower middle income countries	Upper-middle income countries	High income countries
Eritrea	Namibia	Botswana	Cyprus
Liberia	Swaziland	Gabon	Israel
Kenya	Cuba	Seychelles	Kuwait
Ethiopia	Ecuador	Argentina	Qatar
Benin	Belize	Trinidad and Tobago	
Nigeria	Paraguay	Panama	
Cote d'Ivoire	Peru	Turkey	
Senegal	Romania	Croatia	
Mozambique	Latvia	Estonia	
Guinea	Lithuania		
Cameroon	Albania		
Central African Rep.	Philippines		
Nicaragua	Thailand		
Azerbaijan	Tunisia		
Armenia	Jordan		
Nepal	Syria		
Myanmar	Morocco		
Indonesia			
India			
Mongolia			
Cambodia			
Pakistan			
Comoros			
Yemen			
Total = 24	Total = 17	Total = 9	Total = 4

Source: Telecommunications Regulation Database, ITU 2002

Table 8
Countries that prohibited call-back services by income level (2000)

Low income countries		Lower middle income countries		Upper-middle income countries	High income countries
Haiti	Eritrea	Cape Verde	Fiji	Mauritius	Bahamas
Georgia	Cameroon	Swaziland	China	Seychelles	Slovenia
Moldova	Burundi	Equatorial Guinea	Maldives	South Africa	Cyprus
Tajikistan	Burkina Faso	Jamaica	Tonga	Gabon	Greece
Kyrgyzstan	Cote d'Ivoire	Colombia	Iran (Islamic Rep. of)	Botswana	Malta
Uzbekistan	Senegal	Ecuador	Sri Lanka	Antigua and Barbuda	Israel
Armenia	Benin	Belize	Thailand	Dominica	Brunei Darussalam
Azerbaijan	Congo	Honduras	Papua New Guinea	Uruguay	Kuwait
Ukraine	Chad	Bolivia	Philippines	Mexico	Qatar
Indonesia	Zambia	Suriname	Marshall Islands	Panama	United Arab Emirates
Nepal	Mozambique	Peru	Jordan	Grenada	
Lao P.D.R.	Central African Rep.	Cuba	Morocco	Costa Rica	
Viet Nam	Congo (Democratic	Bosnia and Herzegovina	Syria	Venezuela	
Mongolia	Republic)	T.F.Y.R. Macedonia	Egypt	Brazil	
India	Uganda	Lithuania	Tunisia	Hungary	
Bangladesh	Guinea	Kazakhstan	Algeria	Croatia	
Afghanistan	Tanzania	Bulgaria	Djibouti	Slovak Republic	
Cambodia	Ghana	Latvia		Turkey	
Pakistan	Gambia	Belarus		Czech Republic	
Myanmar	Niger	Romania		Poland	
Comoros	Malawi	Albania		Malaysia	
Yemen	Kenya			Oman	
Sudan	Sierra Leone			Saudi Arabia	
Mauritania	Nigeria			Libya	
	Zimbabwe			Bahrain	
	Ethiopia			Lebanon	
	Rwanda				
	Mali				
	Madagascar				
Total = 52		Total = 38		Total = 26	Total = 10

One of the main obstacles in doing empirical international research is in many cases the lack of complete data. This study is not the exception. Although institutions like the World Bank, the ITU, and the IMF collect statistics from more than 200 countries, much of the information is missing. It has been well documented in the statistics field that doing analysis of only those cases that have complete data can lead to biased results. In this study the initial number of countries was 213. The list was reduced to 188 because many of those countries had data on only two or three of the variables that were included in the analysis. The number of countries eliminated should not cause bias in these results because they are either very small economies or are going through major transitions. Examples of countries that were eliminated include Afghanistan, Andorra, Liechtenstein, Iraq, Mayotte, and Andorra. This does not mean that there was complete data for the rest of them. There were some variables for which many data points were missing. Table 10 presents the list of variables and the number of observations that were available. The total number of observations was thus 1128 because data was collected for 6 years for each of these countries.

Table 10
Percentage of missing data per variable

Variable	No. of complete observations	% Missing
GDP per capita	1041	8%
Trade	979	13%
Employment in services	394	65%
Employment in agriculture	414	63%
Employment in industry	416	63%
Competition in international telecom service	916	19%
Intlfinance	488	57%
Number of Faults	666	41%
Privatizatization	885	22%
Universal Service Program	621	45%
Roads	889	21%

VOI regulation	617	45%
Level of ISP competition	258	77%
Call-back regulation	987	13%
Telecommunication revenue	1037	8%
Incoming international traffic	913	19%
Outgoing international traffic	1070	5%
Price of a 3 min call to the U.S.	772	32%
Teledensity	1116	1%
Population	1100	2%

While the models could not have included all the variables there would have been some for which less than 300 observations would have been included. Because missing variables is a common problem, scholars have devised techniques to calculate the missing variables from existing ones. Some methods that have been found to be inadequate (Little & Rubin, 1987; Graham, Hofer & Piccinin, 1994) include ad hoc ones, such as using the mean from the observed values, extrapolating from the latest value available, also known as last-observation-carried-forward (LOCF), and the use of regression analysis to estimate values. For this study these were particularly inappropriate because for some variables there was missing data for two or three consecutive years. This meant that the same value would have been given for the three years in the case of any of the ad hoc or regression methods. The approach used in this project was that of multiple imputation where missing data is generated simultaneously from all the available variables for all the observations and years. The mathematical algorithms that are necessary for multiple imputation are now easier to use thanks to advances in computing. In this project I used the Amelia program developed by Honaker, Joseph, and King (2000).

Infrastructure is measured by the number of telephone lines per 100 inhabitants. Table 11 presents the results per income level of the countries in the regression analysis. It uses a fixed effects model that includes the year dummies to capture the changes in infrastructure deployment. The fixed model was selected because of the recognition that the way technology affects each country will

depend on its specific circumstances. We are thus interested in the differences within each country and how these technologies affect the deployment of infrastructure. The analysis used the following model.

$$\ln teledesity = \beta_0 + \beta_1(\ln gdppc) + \beta_2(trade) + \beta_3(emplservices) + \beta_4(emplagricult)$$
$$+ \beta_5(emplindustry) + \beta_6(\text{int}\, compd) + \beta_7(\ln \text{int}\, lfinance) + \beta_8(\ln trafin) + \beta_9(\ln usacall)$$
$$+ \beta_{10}(\ln population) + \beta_{11}(parcpriva) + \beta_{12}(fullpriv) + \beta_{13}(univservd) + \beta_{14}(voip)$$
$$+ \beta_{15}(callback) + \beta_{16}(y96) + \beta_{17}(y97) + \beta_{18}(y98) + \beta_{19}(y99) + \beta_{20}(y00) \qquad (1)$$

Table 11
Effect of market, organizational, and regulatory conditions on telecommunications infrastructure as measured by teledensity

Teledensity	All countries	Low income	Low middle income	Upper middle income	High income
Telecom revenue	1.046*	0.948	1.033	1.012	1.099
GDP per capita	1.328***	1.613***	0.949	1.094	1.132**
Trade	-0.001**	-0.001	-0.001*	0.000	-0.002***
Employment in services	-0.001	-0.002	0.001	0.000	-0.002
Employment in industry	0.007***	0.010***	0.005**	0.006***	0.002
International Long distance competition	0.028	0.069	0.097**	0.052	-0.026
Financing from abroad	1.026*	1.051	0.995	1.043***	1.006***
International incoming telephone traffic	1.162***	1.182***	1.115***	1.194	1.155
Cost of 3 min call to USA	1.006	1.001	0.997	0.984	0.992

Ln Population	0.897***	1.199	5.812***	0.801***	0.835***
Incumbent privatized	0.062*	0.116*	0.058*	0.017	0.006
Universal Service Fund	0.041*	-0.038	0.005	0.069**	0.057
Internet Telephony Policy	-0.018	0.031	-0.057	-0.026	-0.112**
Call-back policy	0.065	0.152	0.035	-0.084	0.102*
Year 96	0.075***	0.056	0.079**	0.097***	0.055
Year 97	0.157***	0.125*	0.174***	0.229***	0.110**
Year 98	0.253***	0.162*	0.237***	0.363***	0.243***
Year 99	0.383***	0.224**	0.337***	0.523***	0.434***
Year 00	0.535***	0.340***	0.491***	0.720***	0.598***
_cons	-2.132***	-7.486	-27.225***	1.806	0.839
N	1128	366	300	198	258
Within R-sq	0.62	0.55	0.74	0.89	0.69

*Significant at .10 ** Significant at .05

One interesting finding is the way economic factors affect countries in the four income levels. The richer the country is the less that economic factors matter. Telecommunications revenues do not seem to have much effect on infrastructure. For high income and lower middle income countries revenues were non-significant at the 10% level but significant at higher levels. This means that revenues are invested in infrastructure in some countries. GDP per capita is a significant variable and, as expected, higher incomes have a positive effect on infrastructure. Dividing the countries by income levels makes this factor non-significant because there is little variability among them. Employment in industry has a positive impact on teledensity. As stated above, scholars have found a positive relationship between the service economy and teledensity. Employment in services is not significant with the exception of low income countries. All other income levels were significant at a lower confidence level of 15%.

Having large incoming international traffic also positively affects the deployment of infrastructure. This is truer in lower income countries where it is clear that hard currency revenue has an impact. Higher income countries generally originate more international calls than they receive. Having a privatized carrier also has a positive impact on a country's telecom infrastructure particularly in lower income countries, where privatizations have been shown to have a positive effect. With respect to the variables of interest in this research, specifically call-back and Internet telephony, neither was significant. This means that they do not have either a positive or a negative effect on the telecom infrastructure of a country.

The variable corresponding to the level of competition is significant only for low middle income countries. This indicates that competition has a positive effect on infrastructure. Because developing countries have liberalized their markets more slowly than rich economies, the effects of competition are being felt as they have increased teledensity over the years of the study. In many high income countries, however, competition was introduced earlier and teledensity is quite high. Thus, any additional competition may have an effect on prices but not necessarily on the further development of basic telecommunications infrastructure.

The amount of finance received from abroad appears to have an effect in upper income countries only. It is possible that financing from abroad is not used for telecommunication infrastructure projects in the lowest income countries.

The price of a three minute call to the U.S. does not seem to have any effect on infrastructure. In this model universal service was coded as one if the country had a universal service fund and zero if it did not. Universal service funds are still relatively new and thus there are only a few countries that have adopted them. The variable is significant for upper middle income countries, which are also those that have more broadly adopted these programs.

The two variables of greatest interest in this study are call-back and Internet telephony. Neither is significant for all countries except the higher income ones. It is not surprising that call-back has no effect as the technology is no longer new and any negative effects would have been felt in the years before the ones included here. The effects of Internet telephony nonetheless should have been

felt in the years of the study because the technology was first implemented in the mid-1990s. It is interesting to see how the effect of Internet telephony is negative while the effect of call-back is positive in high income countries. The negative effect of Internet telephony is not surprising and could be related to the use of these technologies by people who want to call their home countries without using traditional carriers, which have to pay high settlement charges. Call-back services were favorable to countries such as the U.S. that have lower settlement rates. This thus led to people in high rate countries to use these services, which generated greater traffic for carriers that offered lower rates.

The fact that the coefficient is not significant also does not suggest that it has a positive effect. This is important because some people argue that allowing these technologies in the market will force the incumbent carrier to become more efficient because it is a form of competition. If this had been the case then the coefficient would have been significant with a positive sign. The most likely event is that the level of use is too low to have any impact on infrastructure.

Both call-back services and Internet telephony are expected to have a negative impact on the revenues of carriers. This is represented in the model below. Table 12 shows the regression results for that variable. It is also organized by income level.

$$\ln telrev = \beta_0 + \beta_1(\ln gdppc) + \beta_2(\text{int}\, compd) + \beta_3(\ln \text{int}\, lfinance) + \beta_4(private)$$
$$+ \beta_5(univservd) + \beta_6(voip) + \beta_7(callback) + \beta_8(\ln trafin) + \beta_9(\ln usacall)$$
$$+ \beta_{10}(\ln population) + \beta_{11}(y96) + \beta_{12}(y97) + \beta_{13}(y98) + \beta_{14}(y99) + \beta_{15}(y00) \qquad (2)$$

Table 12
Effect of market, organizational, and regulatory conditions on telecommunications revenue

Telecommunications Revenue	All countries	Low income	Low middle income	Upper middle income	High income
GDP per capita	2.260***	2.703***	0.725	3.025***	2.078***
International Long distance competition	0.052	0.144	-0.024	0.044	0.017
Financing from abroad	0.970*	0.939**	0.946	0.970	0.988
International incoming telephone traffic	1.327***	1.232***	1.376***	1.368***	1.234***
Cost of 3 min call to USA	1.001	0.997	1.010	1.010	0.985
Ln Population	1.744***	0.832	0.556	1.677***	1.829***
Privatized carrier	0.016	-0.083	0.132	-0.058	0.011
Universal Service Fund	-0.027	-0.130**	0.071	0.017	-0.037
Internet Telephony Policy	0.047	0.046	0.086	-0.027	0.023
Call-back policy	0.110*	-0.091	-0.151	-0.047	0.322***
Year 96	0.046**	0.058	0.102	0.100	0.024
Year 97	0.033**	0.053	0.089	0.090	0.088
Year 98	0.083*	0.137	0.140	0.219***	0.091
Year 99	0.081*	0.002	0.202*	0.257***	0.198***
Year 00	0.096*	0.134	0.244*	0.287***	0.103
_cons	-0.809	11.425	24.343	-3.074	0.628
N	1128	366	300	198	258
Within R^2	0.57	0.74	0.22	0.50	0.75

*Significant at .10 ** Significant at .05

The revenue of carriers seems to be affected only by the amount of traffic that goes through the network and the income level of the population. The implementation of universal service policies does not seem to have an effect on revenues. When it does, as is the case in low income countries, the impact is negative. The level of revenues from one year to the next seems to vary as some are able to predict revenue for that year and some are not. This may be a reflection of the volatility of the industry after privatization and liberalization. The two important variables for this study, call-back and Internet telephony, are not significant either except for high income countries where this technology appears to have a positive effect. These two technologies may be used at such low levels compared to the use of traditional communications that it simply has not had an impact on these carriers' revenues.

The final model used in this analysis is a simultaneous equation estimation. This was necessary because the impact that any of these technologies can have on infrastructure is related to how they affect revenues. Thus I used a two stage least square procedure for panel data.

$$\ln tden = \beta_0 + \beta_1(\ln telrev) + \beta_2(trade) + \beta_3(emplservices) + \beta_4(emplagricult) + \beta_5(emplindustry) + \beta_6(\ln \text{int} lfinance) + \beta_7(\ln population) + \beta_8(univservd) + \beta_9(voip) + \beta_{10}(callback) + \beta_{11}(y96) + \beta_{12}(y97) + \beta_{13}(y98) + \beta_{14}(y99) + \beta_{15}(y00) \quad (3)$$

Where:

$$\ln telrev = \beta_0 + \beta_1(\ln gdppc) + \beta_2(\text{int}\, compd) + \beta_3(parcpriva) + \beta_4(fullpriv) + \beta_5(\ln trafin) + \beta_6(\ln usacall) \quad (4)$$

Table 13
Simultaneous equation model of the effects of market, organizational, and regulatory conditions on telecommunications infrastructure with telecom revenue as a nested equation

Teledensity	All countries	Low income	Low middle income	Upper middle income	High income
Telecom revenue	1.888***	1.596***	1.471***	1.181**	1.389***
Trade	0.000	0.001	-0.001	0.000	-0.002***
Employment in services	0.000	-0.002	0.003**	0.000	-0.001
Employment in industry	0.009***	0.011***	0.006**	0.006***	0.002
Financing from abroad	1.044***	1.065*	1.016	1.044***	1.004
Ln Population	0.583***	1.554	7.079***	0.765***	0.764***
Universal Service Fund	0.048	0.028	-0.008	0.079***	0.067*
Internet Telephony Policy	-0.083**	0.011	-0.091**	-0.036	-0.108*
Call-back policy	-0.045	0.195	0.072	-0.060	0.044
Year 96	0.036	0.033	0.046	0.103***	0.053
Year 97	0.117***	0.100	0.148***	0.243***	0.099**
Year 98	0.195***	0.140	0.201***	0.374***	0.231***
Year 99	0.309***	0.260**	0.287***	0.541***	0.404***
Year 00	0.435***	0.311**	0.433***	0.756***	0.616***
_cons	-2.014***	-15.440	-35.394***	3.388	1.190
Obs	1128	366	300	198	258
R-sqr	0.45	0.41	0.56	0.87	0.66

*Significant at .10 ** Significant at .05

The results of this last model are similar to those obtained in the separate models. Call-back is not significant and Internet telephony when allowed appear to have an negative impact on infrastructure for high and low middle income countries but the impact is too small to be of concern to governments. Infrastructure increases every year and all of the coefficients are significant. If any of the two technologies had had a negative impact it would have showed some reduction or perhaps even a negative number.

There were several problems that needed to be overcome in this research. Heteroskedasticity was present, although the model was corrected by the use of a robust regression. Similarly multicollinearity problems were solved by corrections in the model and the elimination of variables because the original design was overspecified. Although the problem of missing data was solved by the use of multiple imputation techniques, the resulting numbers can still result in inaccuracies, even though this method is the best available in statistical research. The results, although consistent with previous research, should be taken with caution.

6. Implications and conclusions

Governments are challenged when new technologies emerge. They are problematic because in many cases these innovations do not fit within the existing policy or regulatory frameworks. Call-back services in the 1980s and Internet telephony in the 1990s are two examples of the many technologies that have had an affect on policy. More recently digital trunking challenged regulators on spectrum allocation. Regulators will face a similar challenge when wireless fidelity (WiFi) becomes more prevalent. In these cases there are concerns about the impact on existing companies and on the regulators themselves, as they do not know how to regulate these new technologies, particularly when existing policies may be difficult to change. There are also cases where the regulator may be sympathetic to the new technology but is pressured by companies to prevent its introduction. In the telecommunications sector this

has been a natural response. Many of these companies have had monopolized markets for many years. They benefited from an unchallenged inflow of revenues and, because of their highly regulated status, they learned to operate and relate to regulators. In a situation where their traditional business models are being threatened, the natural response is to impede change.

Regulators should, however, be concerned about frequently changing policies because laws and regulations are the basis for functioning markets and thus they cannot be changed at will. There are contracts and commitments in place that may prevent regulators from changing policy. In many cases, nonetheless, there simply is no framework that accommodates these new technologies. When a regulator decides to change a rule to accommodate innovation, it may be flooded with lawsuits.

What approach, then, should regulators take? For developing countries the results of this analysis show that at least two technologies, call-back and Internet telephony, have not had negative impact on infrastructure. This shows that the effect that these technologies may have on the existing carriers is, if anything, gradual. It would thus be premature to impede innovation, particularly when benefits to the public are clear. Operators are aware of these technologies and the gradual improvement of these new services should give them time to respond in a manner that strengthens their competitive position. Regulators should thus approach the matter cautiously, simply observing the evolution of the technology as it affects the market and making agreements with operators to review policies within specific periods. If there are signs of a negative impact policies could be revised. Regulators should be prepared to answer carrier's challenges. They may simply follow the current law, which is often broad enough to embrace new technologies. Banning the technologies without evidence of negative effects on society, as opposed to carriers alone, can prevent these countries from incorporating services that would benefit the public.

References

Bernt, P., and Weiss, M., 1993. International telecommunications, 1st edn (Carmel, IN, Sams Publications).

Cawley, R. A., 1997. Internet, lies and telephony, Telecommunications Policy 21, 513-532.

Clark, D., 2001. A taxonomy of internet telephony applications, in: L. W. McKnight, W. Lehr, and D. D. Clark (Eds.) Internet telephony, (Cambridge, MA, MIT Press).

Cowhey, P., 1998. FCC benchmarks and the reform of the international telecommunications market, Telecommunications Policy 22, 899-911.

Frieden, R., 1998. Falling through the cracks - international accounting rate reform at the ITU and WTO, Telecommunications Policy 22, 963-975.

Galal, A., Jones, L., Tandon, P., and Vogelsang, I., 1994. Welfare consequences of selling public enterprises: An emprical analysis (Washington, DC, The World Bank).

Graham, J. W., Hofer, S. M., and Piccinin, A. M., 1994. Analysis with missing data in drug prevention research, in: L. Collins, and L. Seitz (Eds.) National institute on drug abuse research monograph series, (Washington, DC, National Institute on Drug Abuse), pp. 13-62.

Honaker, J., Joseph, A., King, G., Scheve, K., and Singh, N., 2003. Amelia: A program for missing data, Windows Version 2.1. edn (Cambridge, MA., Harvard University,).

ITU Internet reports: IP telephony, 2001. (Eds.), (Geneva, International Telecommunications Union).

Ke, B., 1994. New global network arrangements - regulatory and trade considerations, Telecommunications Policy 18, 378-396.

Kelly, T., McTaggart, C., Petrazzini, B., Shaw, R., and Woodall, M., 2001. ITU Internet reports: IP telephony (Geneva, International Telecommunications Union).

King, G., Honaker, J., Joseph, A., and Scheve, K., 2001. Analyzing incomplete political science data: An alternative algorithm for multiple imputation, American Political Science Review 95, 49-69.

King, G., Tomz, M., and Wittenberg, J., 2000. Making the most of statistical analysis: Improving interpretation and presentation, American Journal of Political Science 44, 347-361.

Kiser, C. R., and Collins, A. F., 2003. Regulation on the horizon: Are regulators poised to address the status of ip telephony?, Communications Law Conspectus 19, 19-44.

Lam, P.-L., 1997. Erosion of monopoly power by call-back - lessons from Hong Kong, Telecommunications Policy 21, 693-695.

Little, R. J. A., and Rubin, D. B., 2002. Statistical analysis with missing data, 2nd edn (New York, Wiley & Sons).

Mason, R., 1998. Internet telephony and the international accounting rate system, Telecommunications Policy 22, 931-944.

Mbarika, V., 1999. Factors that affect growth of teledensity in least developed countries, Paper presented at: 22nd Conference on Information Systems Research (IRIS 22) (Jyvaskyla, Findland).

Mbarika, V., Byrd, T., and Raymond, J., 2002. Growth of teledensity in least developed countries: Need for a mitigated euphoria, Journal of Global Information Management 10, 14-28.

McGarty, T., and McKnight, L. W., 2001. Virtually global telcos: International internet telephony architectures, in: L. W. McKnight, W. Lehr, and D. D. Clark (Eds.) Internet telephony, (Cambridge, MA, MIT Press).

McKnight, L., and Leida, B., 2001. Internet telephony service providers, in: L. W. McKnight, W. Lehr, and D. Clark (Eds.) Internet telephony, (Cambridge, MA, MIT Press), pp. 193-213.

Megginson, W. L., Nash, R. C., and Van Randerborgh, M., 1994. The financial and operating performance of newly privatized firms: An international empirical analysis, Journal of Finance 49, 403-452.

The missing link, 1984. (Eds.), (Geneva, Independent Commission for World Wide Telecommunications Development (The Maitland Commission)).

Moore, D. W., 1997. Regulation of the internet and internet telephony through the imposition of access charges, Texas Law Review 76, 183-214.

Ramamurti, R., 1996. Privatizing monopolies: Lessons from the telecommunications and transport sectors in latin america (Baltimore, MD, The Johns Hopkins University Press).

Ros, A., 1999. Does ownership or competition matter? The effects of telecommunications reform on network expansion and efficiency, Journal of Regulatory Economics 15, 65-92.

Sharifi, H., 2001. Internet telephony carrier strategies, in: L. W. McKnight, W. Lehr, and D. Clark (Eds.) Internet telephony, (Cambridge, MA, MIT Press), pp. 301-333.

Silber, S. C., 1996. The fcc's call-back order: Proper respect for international comity?, George Washington Journal of International Law & Economics 30, 96-195.

Statistics of communications common carriers, (Eds.), (Federal Communications Commission).

Telecommunication regulatory database, 2002. (Eds.), (Geneva, International Telecommunications Union).

Vickers, J., and Yarrow, G., 1988. Privatization: An economic analysis (Cambridge, MA, MIT Press).

Weinberg, J., Internet telephony regulation, in: L. MCKnight, W. Lehr, and D. Clark (Eds.) Internet telephony, (Cambridge, MA, MIT Press).

Wellenius, B., 1989. The impact of modern telecommunications (Eds.), IEEE Technology and Society Magazine, pp. 3-6.

World telecommunication indicators, 2002. (Eds.), (Geneva, International Telecommunications Union).

World telecommunications development report, 1994. (Eds.), (Geneva, International Telecommunications Union).

Yatrakis, P., 1992. Determinants of the demand for international telecommunications, Telecommunications Journal 39, 732-746.