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Κατεύθυνση της Οικονομίας με Έμφαση στα Χρηματοοικονομικά

ΜΕΤΑΠΤΥΧΙΑΚΗ ΕΡΓΑΣΙΑ

ΘΕΩΡΗΤΙΚΗ ΑΝΑΛΥΣΗ ΤΗΣ ΖΗΤΗΣΗΣ ΓΙΑ ΕΥΡΥΖΩΝΙΚΕΣ ΥΠΗΡΕΣΙΕΣ ΣΤΗΝ ΕΛΛΑΔΑ

ΓΚΕΛΜΠΟΥΡΑΣ ΔΗΜΗΤΡΙΟΣ

ΕΠΙΒΛΕΠΩΝ ΚΑΘΗΓΗΤΗΣ :
ΧΡΙΣΤΟΠΟΥΛΟΣ ΑΠΟΣΤΟΛΟΣ

Αθήνα, Απρίλιος 2011

Περίληψη

Η παρούσα μεταπτυχιακή εργασία έχει σκοπό να αναλύσει θεωρητικά την ζήτηση για ευρυζωνικές υπηρεσίες πρόσβασης (κυρίως η τεχνολογία ADSL - Asymmetric Digital Subscriber Line – Ασύμμετρη Ψηφιακή Συνδρομητική Γραμμή, καθώς είναι η πιο διαδεδομένη ευρυζωνική υπηρεσία τα τελευταία οκτώ χρόνια στην Ελλάδα) στην Ελληνική αγορά βασιζόμενη στις σχετικές εργασίες που έχουν γίνει για την περίοδο 2000 έως 2010, στην Ευρώπη, στις Ηνωμένες Πολιτείες της Αμερικής, στην Ιαπωνία και στη Ελλάδα. Έχει γίνει μια παρουσίαση των οικονομετρικών μεθόδων οι οποίες έχουν χρησιμοποιηθεί στα άρθρα που μελετάμε καθώς επίσης και μια προσπάθεια να συγκεντρώσουμε αυτές τις μελέτες και να παρουσιάσουμε ένα οικονομετρικό μοντέλο το οποίο μπορεί να χρησιμοποιηθεί στη περίπτωση της Ελλάδας. Με αυτό το μοντέλο θα μπορούμε να υπολογίσουμε την ζήτηση για υπηρεσίες ADSL χρησιμοποιώντας στοιχεία τα οποία μπορούμε να βρούμε από τους διάφορους Τηλεπικοινωνιακούς Παρόχους (ISPs) και ειδικότερα από τον ΟΤΕ, ο οποίος είναι ο κύριος πάροχος Τηλεπικοινωνιών στην Ελλάδα. Τα στοιχεία αυτά είναι ο αριθμός των συνδρομητών ADSL σε μηνιαία βάση, καθώς επίσης και σχετικές τιμές σύνδεσης ανά ταχύτητα σύνδεσης σε συνδυασμό με μακροοικονομικά στοιχειά όπως είναι το ΑΕΠ και η ανεργία. Βασικός μας στόχος είναι να συνδυάσουμε κάποια μοντέλα που έχουν χρησιμοποιηθεί σε σχετικές μελέτες και να τα προσαρμόσουμε στα δεδομένα της Ελληνικής Τηλεπικοινωνιακής αγοράς ώστε να υπολογίσουμε την εξέλιξη της ευρυζωνικότητας στην Ελλάδα.

Ο βασικός μας στόχος είναι να ερευνήσουμε ορισμένα άρθρα σχετικά με τους βασικούς παράγοντες οι οποίοι επηρεάζουν τη ζήτηση για υπηρεσίες ADSL και ειδικά εξετάζουν τις πρόσφατες δουλειές που έχουν γίνει στην Ελληνική αγορά, κατά την διάρκεια των τελευταίων ετών, οι οποίες αφορούν την προσφορά και την ζήτηση της Τηλεπικοινωνιακής αγοράς και να εκτιμήσουμε την εξέλιξη της ευρυζωνικότητας στην Ελλάδα.

Abstract

This postgraduate thesis is about analyzing theoretically the demand for broadband services (mainly ADSL service, since it is the most known broadband service in the past eight years in Greece) in the Hellenic market from related works made by other studies during the period 2000 to 2010, in Europe, United States of America, Japan and Greece.

We have made a presentation of the econometrical methods used in those studies and there has been also an effort to summarize those studies and present an econometrical model that can be used in the case of Greece, which can estimate the demand for ADSL services using data that can be found from Internet Service Providers (ISPs) and mainly from incumbent operator Hellenic Telecommunication Operator HTO, ('OTE'- the main ISP during the start of ADSL) such as monthly data for the number of ADSL subscribers per connection speed as well as their relevant prices for ADSL speeds provided combined with other economical factors (such as GDP, Unemployment, etc.) provided form the National Statistician Authority ELSTAT . Our main target is to connect some models used in related articles and perform them in the Hellenic telecommunication Market so as to estimate the evolution of broadband in Greece.

Broadband access has shown a remarkable increase in Greece during the past years. The 50% of Greek households have a possession of a personal computer, and 39% of households have an Internet connection. More than 31% of households are equipped to use ADSL service, and subscription charges have become very low. Factors promoting Greek broadband lie in deregulation by the Government, competition among telecommunication carriers and technical development. HTO ('OTE') was the first to launch the ADSL access technology in Greece in the first half of 2003.

Our main target is to investigate some papers about the key factors that influence the demand for ADSL services and especially examine the late work that has been done to the Hellenic Market during the last years concerning the demand and supply of the telecommunication market and to estimate the evolution of broadband in Greece.

This postgraduate thesis is divided in the following sections. In Chapter One there has been an introduction to broadband, especially ADSL and the other forms of broadband. Also there is presented the role of the Local Loop Unbundling (LLU) which was obliged from the National Regulatory Authority "EETT". We present through some data gathered from EETT the Position of Greece in EU Member States, the broadband penetration rate, and the increase in broadband penetration rate in the EU Member States per year, also the broadband Lines by Technology and the speeds of ADSL service (for the period 2006-2009). Then there has been a reference to the main three Internet Service Providers in Greece. It is also introduced the recent developments in Telecommunications and the need for analyzing the demand for broadband Services from related studies. In Chapter Two we

present the literature review used divided in the works done in Europe, in the United States of America, in Japan and on the ones those established in Greece. After, we refer to the case of Greece extensively. Finally, in Chapter Three we present the econometric model that can be used in the case of Greece, which can be used so as to estimate the demand for ADSL services, using data that can be provided from Internet Service Providers (ISPs). This can be done by summarizing the work that has been made from other related studies.

1. Chapter 1

1.1 Introduction

Broadband access is a vehicle that allows the delivery of an entirely new breed of media services and communications oriented applications. It is these new services and applications that differentiate broadband from dial-up Internet access and give consumers a reason for subscribing to broadband. Audio and video being the obvious cornerstones of this high-speed revolution, speedy connections coupled with always-on access improve the consumer multimedia experience and change the types of business models that are viable in the interactive marketplace. Moreover, it is commonly accepted that broadband access constitutes a key factor in the effort of economic growth and performance enhancement. Broadband shrinks the world and enables telecommuting for collaborative projects across countries or across the globe and therefore infuses capital into the markets.

Internet access in Greece relied on PSTN/ISDN modem dial-up until 2003, when ADSL was commercially launched in Greece by the incumbent operator HTO “OTE”. ADSL is currently the main broadband standard. The Greek broadband market is still under development, both in terms of size and competitive dynamics. The Greek incumbent HTO has largely been blamed for stalling ADSL deployment since 2003. But in 2007, the national regulator authority “NRA”, know and as EETT (National Committee Of Telecommunication and Post Office) finally set Greece’s broadband market on the path to fair network access and more competition. The two key events in 2007 were the transposition of the EU framework for Electronic Communications into Greek law and new regulations on Local Loop Unbundling (LLU).

In 2007, broadband penetration in Greece followed a spectacular course, similar to that of 2006. By the end of the year, broadband connections had more than doubled, and from 490,000 in the end of 2006, had exceeded 960,000 active connections by mid-November 2007.

The role of the EETT was instrumental for reducing prices and increasing capacities. In early 2007, the telecoms regulator forced the incumbent to open its network to competitors, enabling them to offer their own services. It also set very low charges for the provision of the Local Loop Unbundling (LLU) service.

Many alternative providers and OTE competitors invested in the unbundling of the local loop. Forthnet, Hellas OnLine and other alternative providers invested in this field and started to appeal to the market, thanks to their attractive services. “Double play”, i.e. the provision of telephony and broadband internet access services, was introduced to the Greek way of living at very attractive rates, with unlimited airtime for national calls. Thus, from mid-2007 alternative providers command the lion's share in new broadband connections, offering, at the same time, telephony services. Moreover, according to EETT data, OTE's competitors control 25% of extant broadband connections. And, apart from mobile telephony, OTE is for the first time facing serious competition in the fixed telephony market. The incumbent's response to the competition was swift, and included reduced rates, competitive to those of other market players.

At the end of 2007, OTE made deep cuts in its pricing structure, reducing charges by as much as 44%. Furthermore, it started introducing its own double play packages, while the new "triple play" package - i.e. the combination of fixed telephony, mobile telephony, and broadband internet access - in early 2008.

The rapid increase in LLU lines has contributed to broadband growth. At the end of 2008 they constituted 36% of all broadband lines (compared to 20% in 2007), and their share increased to 45.8 % by June 2010.

ADSL2+ (the new ADSL standard) networks have become quite wide spread in Greece, which enabled the launch of IPTV – Internet Protocol television, VoIP – Voice Over Internet Protocol and fixed-mobile telephony bundles. As Greece has no cable TV operators, the incumbent and alternative operators are using faster xDSL (the forms of DSL service) networks to launch bundled offerings.

The absence of fixed alternative networks remains a significant weakness. Greece is the only EU country where broadband services via technologies other than DSL are almost non-existent. The government has big plans for making Greece a fibre nation. In early 2009, it announced plans to pass 2 million homes during the next seven years with fibre network in Athens, Thessaloniki, and 50 other cities and towns across Greece based on an open network model. The project's success will depend on support from the private sector. Construction of the network was due to start in 2010, but was postponed until 2011 due to the dire economic situation.

It is worth adding that in Greece there have long been strong disagreements between the incumbent operator HTO and the regulatory authority EETT concerning the provision of unbundled local loops to alternative operators and leased line prices. In EETT's view, the incumbent has delayed the process of local loop unbundling and charges wholesale rates that are above cost. In contrast, the incumbent points to the relatively low level of investment by alternative operators in building out their own networks as evidence that the incumbent's wholesale rates have been set below cost by EETT. This has impeded the development of infrastructure competition, since alternative operators have little incentive to invest. EETT appears to have no strategy for encouraging alternative operators to climb the ''ladder of investment''.

1.2 Definition of broadband

A telecommunication connection is called broadband provided it gathers the following two characteristics:

a) Offering uninterrupted access to the Internet.
b) Providing high level data transmission to the user so that the user may have access interactive content-rich, internet–based services (e.g. telephony and video–telephony, interactive TV and video–on–demand, surfing the World–Wide-Web).

Broadband market development is a top priority for the European Union and for all developing countries since it is connected to the increase of financial wellbeing, the creation of new job positions and the improvement of the citizen’s standard of living. The benefits of broadband are numerous, covering various sectors of financial and social life. In the public sector for example, broadband allows the development of e-government services that improve services to citizens and businesses, while at the same time improve the public sector’s function processes.

In the fields of health and education respectively, broadband allows the provision of top quality services to remote, through the use of telemedicine and tele-education.

Moreover, in the business sector, broadband offers new possibilities for promotion and supply of products and services, with the use of e-commerce applications. At the same time, the means of operation for businesses are changing thanks to the tele-working and tele-conference applications.

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Cable modem

A broadband technology that uses access lines for cable television (CATV). Although traditional CATV networks need to be upgraded with a separate voice line to provide interactive communication services like telephony and Internet access, new networks use the same coaxial cable to provide simultaneous transmission of data, television and voice. Connection speeds range from 1 to 10 Mbps.

Fiber To The Home (FTTH)

A fiber optic technology similar to standard cable that allows for transmission speeds of up to 10 Gbps. Fiber optic cables are rolled out up to home of the consumer and can carry video, data, voice and interactive video telephone services.

Satellite

It is a broadband technology that uses satellite TV equipment to carry data. At the moment the majority of services based on satellite technology are one-way (i.e., they only allow for downstream transmission) and need a dial-up connection for the return channel. The downstream speed ranges between 300 Kbps and 2 Mbps. This technology is considered to be particularly effective for servicing rural areas where other technologies are too expensive to be put in place.

1.3 DSL (Digital Subscriber Line)

DSL (Digital Subscriber Line) is the technology that enables high-speed data transfer and rapid access to the Internet via telephone lines, with a secure connection straight into the high-speed network. DSL has raised its importance in the data communication industry.

DSL is an important technology due to its ability to provision multiple services such as voice, data, and video high – bandwidth services at a very low deployment cost. DSL is a dedicated link that establishes a direct connection between the customer and the carrier, providing broadband access to the end user through a DSL modem installed at the customer's premises. DSL is a broadband technology that allows for high- speed Internet connectivity over traditional twisted-pair copper telephone lines, thus eliminating the need for costly infrastructure upgrades common with other technologies. The ability to implement DSL service within the confines of existing telephone lines makes it both affordable and practical for small business and residential homes, allowing for high- speed connectivity for interactive gaming, on-demand streaming audio and video entertainment, and for downloading huge files in seconds instead of minutes. Being able to deliver multimedia entertainment, information and services will become increasingly important as phone companies and Internet Service Providers (ISPs) look to new markets and new applications for continued revenue growth and increased customer demand for fast, reliable access to data and entertainment.

A DSL supports multiple data communication accesses simultaneously, including Internet access, telephone communication, and cable television connection. DSL is a collective term referring to all types of DSL and is synonymous with the acronym xDSL. DSL is the technology that enables high-speed data transfer and rapid access to the Internet via telephone lines, with a secure connection straight into the high-speed network.

DSL performs a variety of functions and tasks. It enables analog and digital signals to travel over a copper wire telephone line simultaneously. In layman terms, this means that one can access the Internet while using the telephone. It provides for constant Internet connection for one flat monthly fee. Because no dial-up is necessary, busy signals, waiting for a connection and drop-offs are no longer an issue. DSL is ideal for interactive multimedia, 3-D, and real-time applications due to its high bandwidth capabilities. One DSL line can provide multiple users to conduct Internet access.

Besides DSL and cable, there are newer platforms able to provide broadband access. These upcoming platforms include optical fibre and wireless technologies, such as third-generation (3G) mobile telecommunications or WiMax. In practice, however, they still play a relatively minor role in most countries.

Advantages of DSL

1. *Low service charges*

The primary advantage of DSL is its low price option for Internet access and transport. DSL service provides an inexpensive way for small businesses and home users to get fast access to the Internet. This is partly because the line charge from the phone companies is low. Also, major phone companies and Internet service providers are competing in this new service market.

2. *Large bandwidth*

Another advantage of DSL is its large bandwidth. This enables continuous transmission of motion video, audio, and even 3-D effects. A DSL line can carry both data and voice signals, and the data part of the line is continuously connected. The large bandwidth of DSL also allows the connection to be more than 50 times faster than an ordinary 56 kbps modem.

3. *High security*

The high security in DSL is another advantage. Each subscriber of the cable network can be configured and computers on the cable network are left visibly vulnerable and are susceptible to break-ins as well as data destruction.

Alternatives to DSL technology

In addition to DSL, business users can select other telecommunications technologies for Internet accesses, including analog modems, Integrated Services Digital Network (ISDN), cable modems, and wireless communication.

1.4 Technologies

There are various forms of DSL:

- Asymmetric DSL (ADSL),
- High Rate DSL (HDSL),
- Symmetric DSL (SDSL) and
- Very High Data Rate DSL (VDSL),

Which are able to provide connection speeds ranging from 256 Kbps to 52 Mbps.

Asymmetric DSL (ADSL) indicates that the speeds for uploading and downloading data are different. ADSL provides a higher bit rate downstream than upstream. Rate-adaptive DSL shows that the transmission speed will vary between a range of frequencies depending on the speed needed for uploading or downloading data.

In Greece the most known technology of broadband connection is the one that is based in the use of the telephone network and is known as ADSL (Asymmetric Digital Subscriber Line).

ADSL (Asymmetric Digital Subscriber Line).

ADSL as described in reference [1.] is one form of the Digital Subscriber Line telephony, a data communications technology that enables faster data transmission over cooper telephone lines than a conventional voice band modem can provide. It does this by utilizing frequencies that are not used by a voice telephone call.

ADSL is quickly growing in popularity, as evidence by the number of users applying to local offerings and the ISPs signing on to support the service. The availability of megabit connectivity to the average household opens up a wealth of new services and enables true convergence between Internet content and media. For the first time, high-quality video streaming becomes a reality, and the ‘waiting’ experienced when browsing graphic-intensive catalogs is a thing of the past. ADSL is therefore an important technology to understand in terms of both standardization, and more importantly, forming a basis for high-speed Internet Services.

There is a real need for the increased bandwidth at lower cost provided by ADSL. The time ripe for development due to the current competitive environment, and both ADSL transport providers as well as ISPs may achieve acceptable returns on investment when offering the service. Due to new applications and more pervasive use of the Internet, demand will only grow. This, combined with a growth in the number of providers that encourages price competition, will further help generate demand.

ADSL advantages

ADSL is attractive to both telecommunications providers and users, because it solves two problems simultaneously.

1. It provides a simple, affordable mechanism to get more bandwidth to end users: both residential and small – to medium –size business. This is increasingly important for Internet access, remote access to corporate servers, integrated voice /data access, and transparent LAN interconnection.
2. It enables carriers to offer value-added, high – speed networking Services, without massive capital outlays, by ‘leveraging’ thee cooper loop.

ADSL characteristics [2.]:

- **Asymmetric**

The data can flow faster in one direction than the other. More precisely, data transmission is faster downstream (to the user) to the subscriber than upstream (from the user). Customers do not need a high bi-directional transmission speed. They actually connect to the Internet in a relatively passive mode because the amount of data they download is enormously higher than the amount of data they are transmitting.

- **Digital**

No type of communication is transferred in an analog method. All data is purely digital, and only at the end, moduled to carried over the line.

- **Subscriber Line**

The data are carried over a single twisted pair cooper loop to the subscriber’s premises.

ADSL applications:

- ***Delivering Multicast Video over ADSL***

Streaming video requires high downstream bandwidth, and relatively small upstream bandwidth. As a result, ADSL, being the most available DSL service in the market to date who offers great downstream bandwidth, is therefore most – suited to deliver multicast video services.

- ***Voice over DSL (VoDSL)***

Voice over DSL is telephony to convert voice calls into digital data packets and transmit them as multiple calls (lines) over a single cooper line, thus enabling Service Providers to offer consumers several phone lines in additional to the standard POTS. This can be done, by using the extra DSL bandwidth that is not used for data to implement voice transmission. For greater efficiency, the bandwidth should be allocated dynamically, so that bandwidth is consumed only when a call is active.

LLU (Local Loop Unbundling)

The main factor for Broadband development is the Local Loop Unbundling (LLU). LLU is the possibility of other Telecommunications Providers than HTO (Hellenic Telecommunication Organization in Greek OTE) to use the cable (Local Loop) that connects the subscriber's location with HTO's Local Exchange. Through the LLU, consumers in Greece may select different telecommunication providers than HTO, for the provision of fixed telephony as well as other services such as the so-called "fast" internet, Internet telephony (VoIP) and digital television through the internet (IPTV).

Making VoIP calls requires a broadband connection (e.g., cable modem or DSL service) at the originating end (i.e., at the premises of the subscriber initiating the call). VoIP converts analog signals placed over an originating end-user's telephone handset into digital signals or ''packets,'' which are then transported (or ''routed'') over the Internet to the call recipient. At the terminating end of the call (i.e., at the premises of the subscriber receiving the call), VoIP converts the digital packets back into an analog signal which can be received by an ordinary telephone handset. Concerns have been raised regarding the sustainability of VoIP as a source of intermodal competition in wireline telephony. **(Paul R. Zimmerman) [4.]**

LLU was promoted by enforcing HTO to provide the ''last mile" to other operators and furthermore, to be bound to maintain it on a monthly fee set and controlled by the regulator. This action encouraged private providers to invest on broadband technology and favored the diffusion of sites where broadband access was available. (ΦΕΚ 620/Β/25-4-2007). Until the end of 2006 HTO was the main Internet ISP (Internet Service Provider) of broadband connection (95.3%). The DSL connection with LLU was 4% and with other technologies 0.7%.

1.5 Position of Greece in EU Member States – Broadband Penetration Rate - Increase in broadband penetration rate in the EU Member States per year (period 2006-2009)

1.5.1 Evolution of Broadband Lines

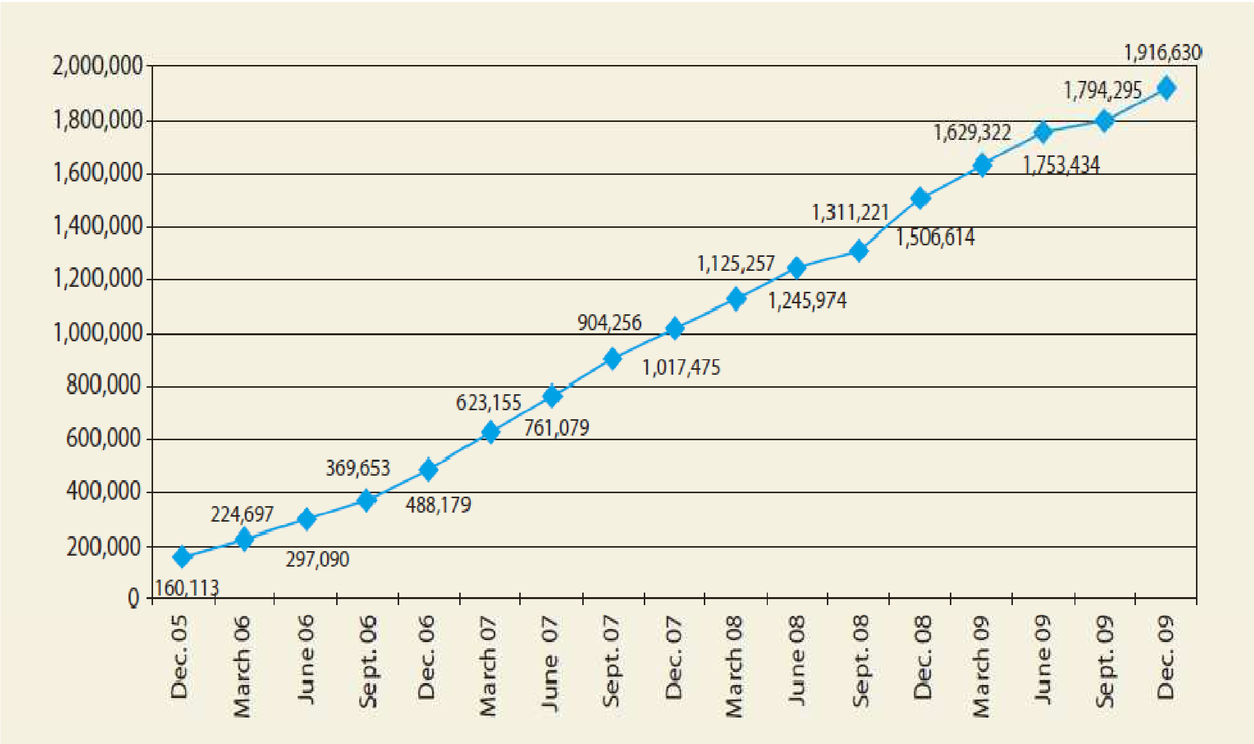
The broadband market kept growing in 2009. On 31-12-2009 broadband connections reached 1,916,630 compared to 1,506,614 on 31-12-2008, registering an annual increase of 27% (Charts 1 and 2). Respectively, broadband penetration amounted to 17% on 31-12-2009 compared to 13.4% on 31-12-2008 (Chart 3). The growth of the broadband penetration rate in Greece during 2009 (3.6%) was the third highest in the EU and substantially higher than the European average (2%). This is an indication of the ongoing convergence of Greece with the rest of Europe that started in 2007.

However, this convergence is not reflected in any improvement of the country's ranking in terms of broadband penetration. Greece remains in the 24th place in the relevant ranking with 17%, compared to Portugal which is in the 23rd place with 18.6% and compared to a European average of 24.8%.

Last, it should be noted that the slow decline in the growth rate of broadband penetration (4.7% in 2007, 4.3% in 2008 and 3.6% in 2009) may be an indication of the gradual saturation of the market.

In the chart following we see the evolution of broadband lines during the year period 2006-2009. On 31-12-2009 broadband connections reached 1,916,630.

Chart 1: Evolution of Broadband Lines

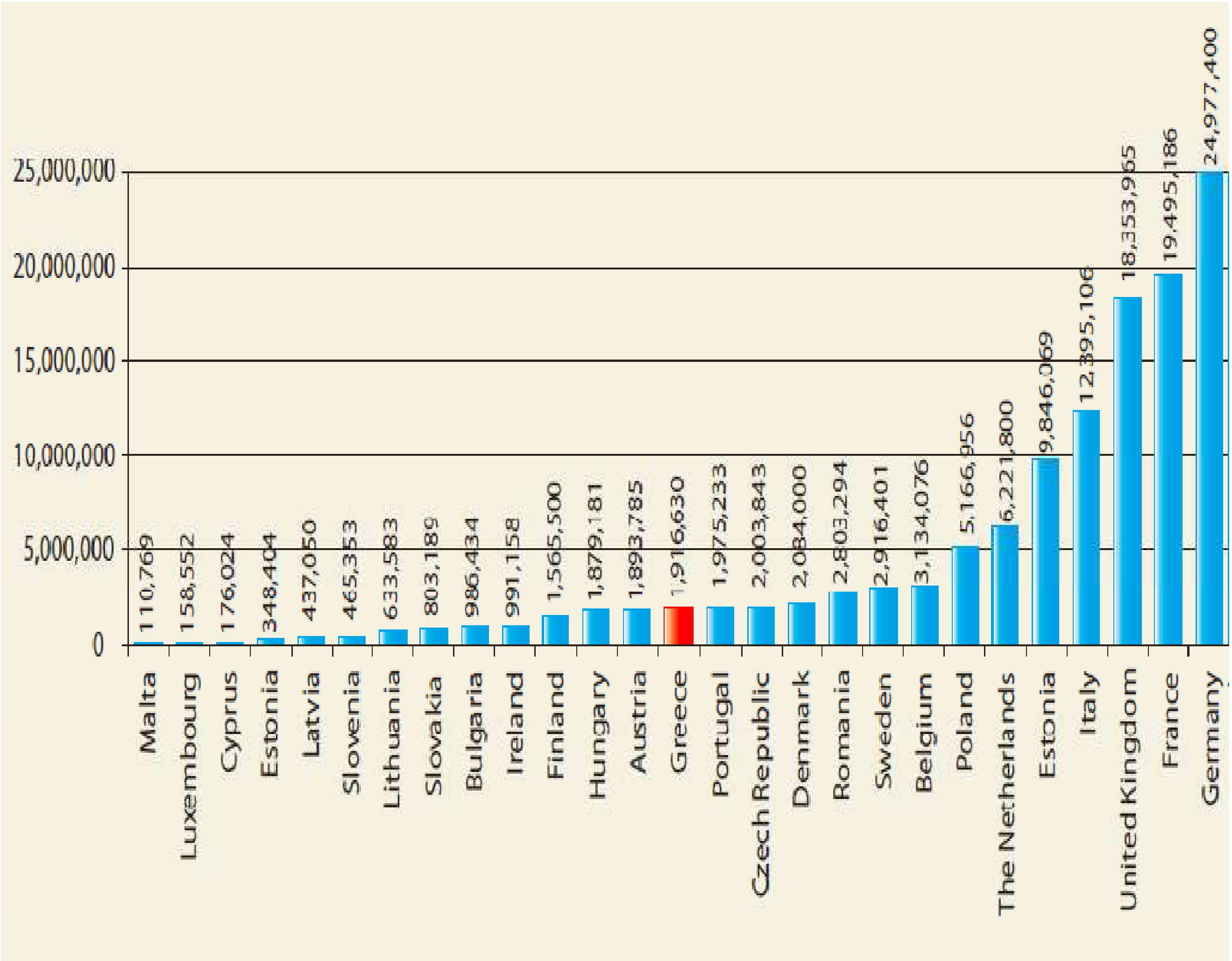


Source: EETT [3.] (based on licensed providers' data).

2007 is characterized by the impressive growth of the broadband market that exceeded 1,000,000 lines and started converging for the first time with the rest of Europe. Tis is due to the telecommunication regulator (EETT) which forced the incumbent (HTO – OTE") to open its network to competitors, enabling them to offer their own services. It also set very low charges for the provision of the Local Loop Unbundling (LLU) service. Specifically, the number of broadband lines during 2007 over doubled and reached 1,017,000 lines compared to 488,000 lines at the end of 2006, having increased 108%

Then we present the position of Greece by broadband lines from the entire EU Member States.

Chart 2: EU Broadband Lines by Member State on 01-01-2010

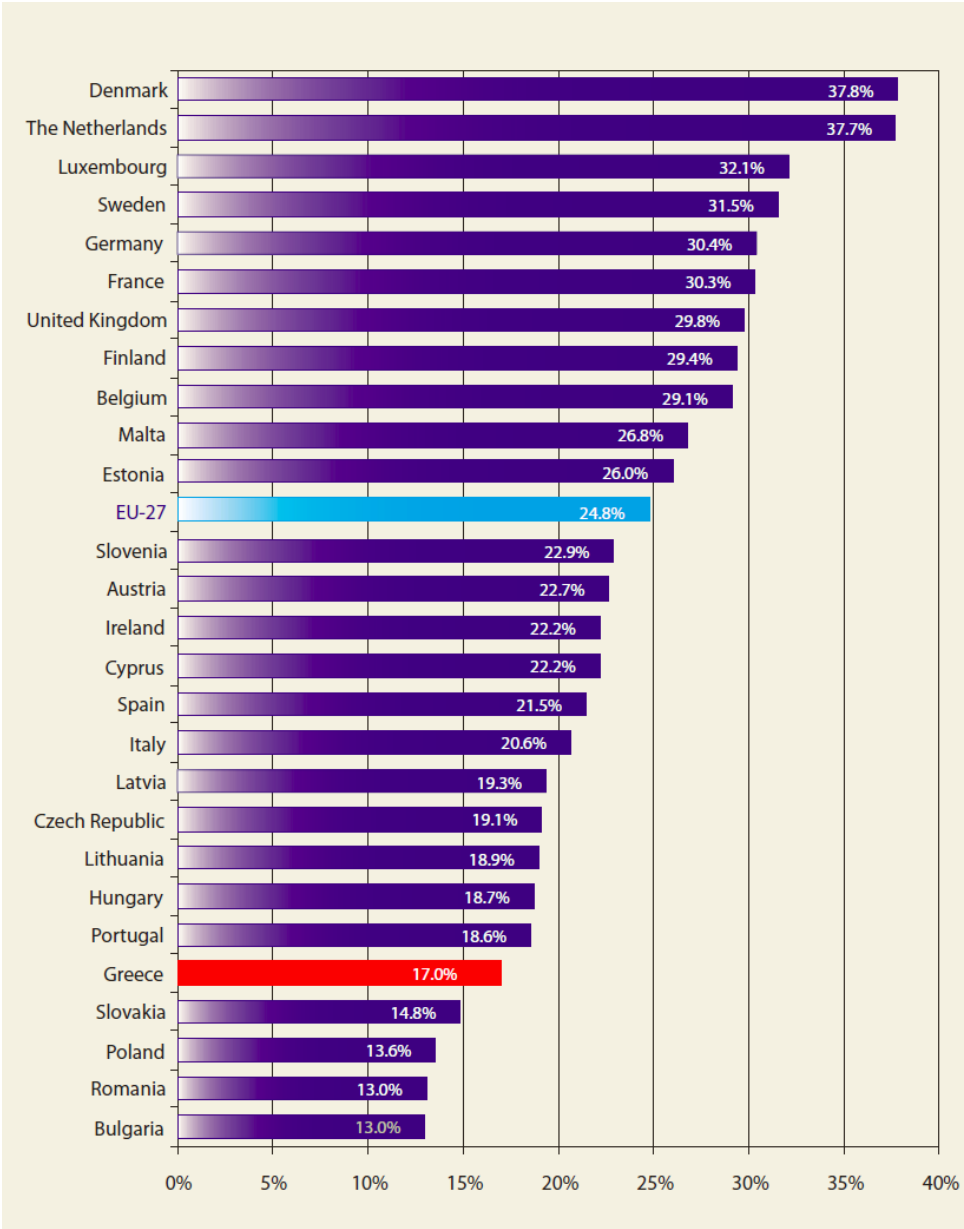


Source: 15th European Commission Implementation Report.

1.5.2 Broadband penetration

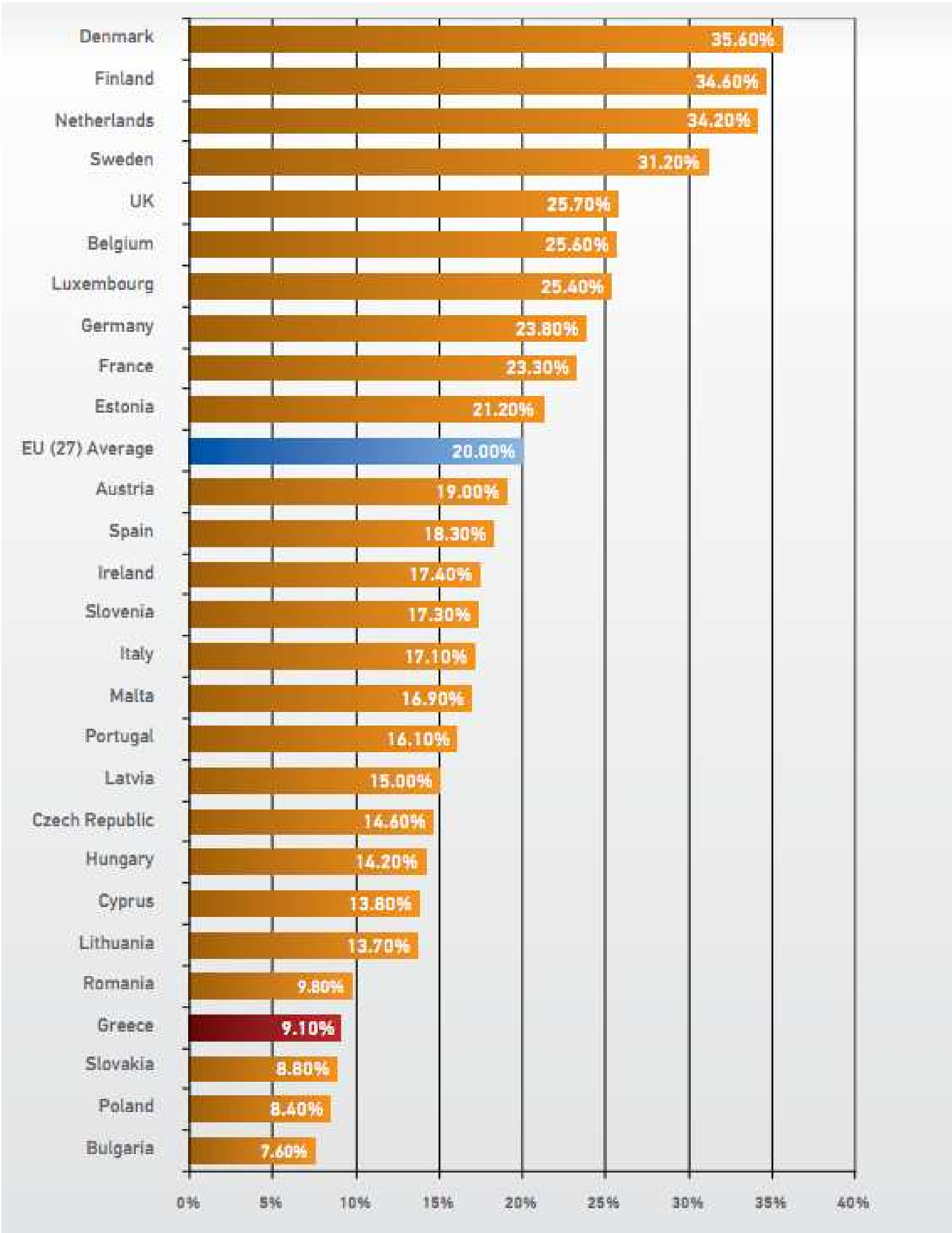
Respectively, broadband penetration amounted to 17% on 31-12-2009. The chart following shows the broadband penetration of EU Member States from the 15th European Commission Implementation Report (January 2010).

Chart 3: Broadband Penetration Rate on 01-01-2010



Source: 15th European Commission Implementation Report.

The increase by 4.7 units in the broadband penetration rate in 2007 was among the higher in the EU and considerably higher than the respective European average increase (3.8 units), a fact that signals the convergence of the Greek with the European broadband market.



Broadband Penetration Rate in 01-01-2008

The growth of the broadband penetration rate in Greece during 2009 (3.6%) was the third highest in the EU and substantially higher than the European average (2%). This is an indication of the ongoing convergence of Greece with the rest of Europe that started in 2007.

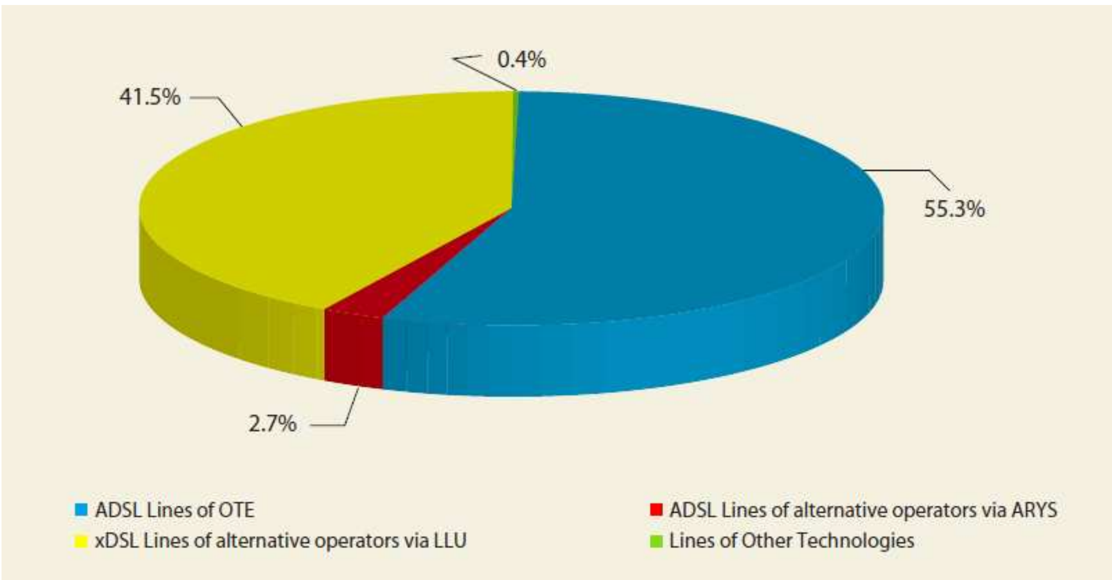
Chart 4: Annual Increase in Broadband Penetration Rate in Greece and the EU (broadband lines per 100 inhabitants)

Source: 15th European Commission Implementation Report.

1.5.3 Broadband Lines by Technology

The xDSL lines via LLU kept rising significantly amounting to 41.5% of broadband lines on 31-12-2009 compared to 36% on 31-12-2008 (Charts 5 and 6). In contrast, the percentage of OTE's retail ADSL lines fell to 55.3% of broadband lines on 31-12-2009 compared to 57.3% on 31-12-2008 but still kept the biggest share in the broadband market. The percentage of wholesale ARYS lines (bitstream) fell even more, dropping to 2.7% of broadband lines on 31-12-2009 compared to 6.3% on 31-12-2008. It is noteworthy that wholesale ARYS lines are the only ones who manifest a decline not just in percentage terms but also in absolute terms (Chart 6). Finally, the level of broadband lines of other technologies remains very low at a percentage of 0.5% that is by far the lowest among EU member states (Chart 7).

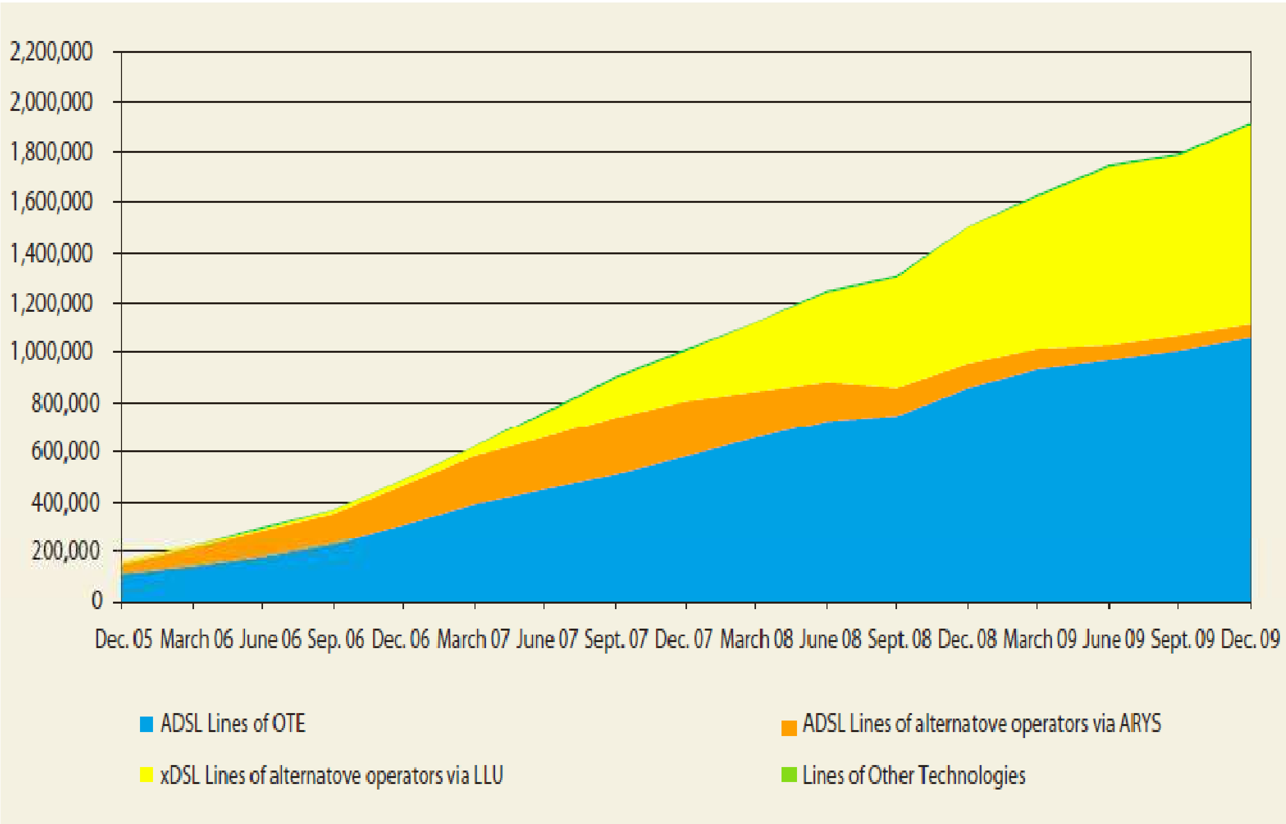
Chart 5: Distribution of Broadband Lines by Technology, December 2009



Source: 15th European Commission Implementation Report.

The evolution of broadband lines per technology is illustrated in the following Chart. Again we see that the year 2007 was the year that LLU appeared in the Hellenic Market.

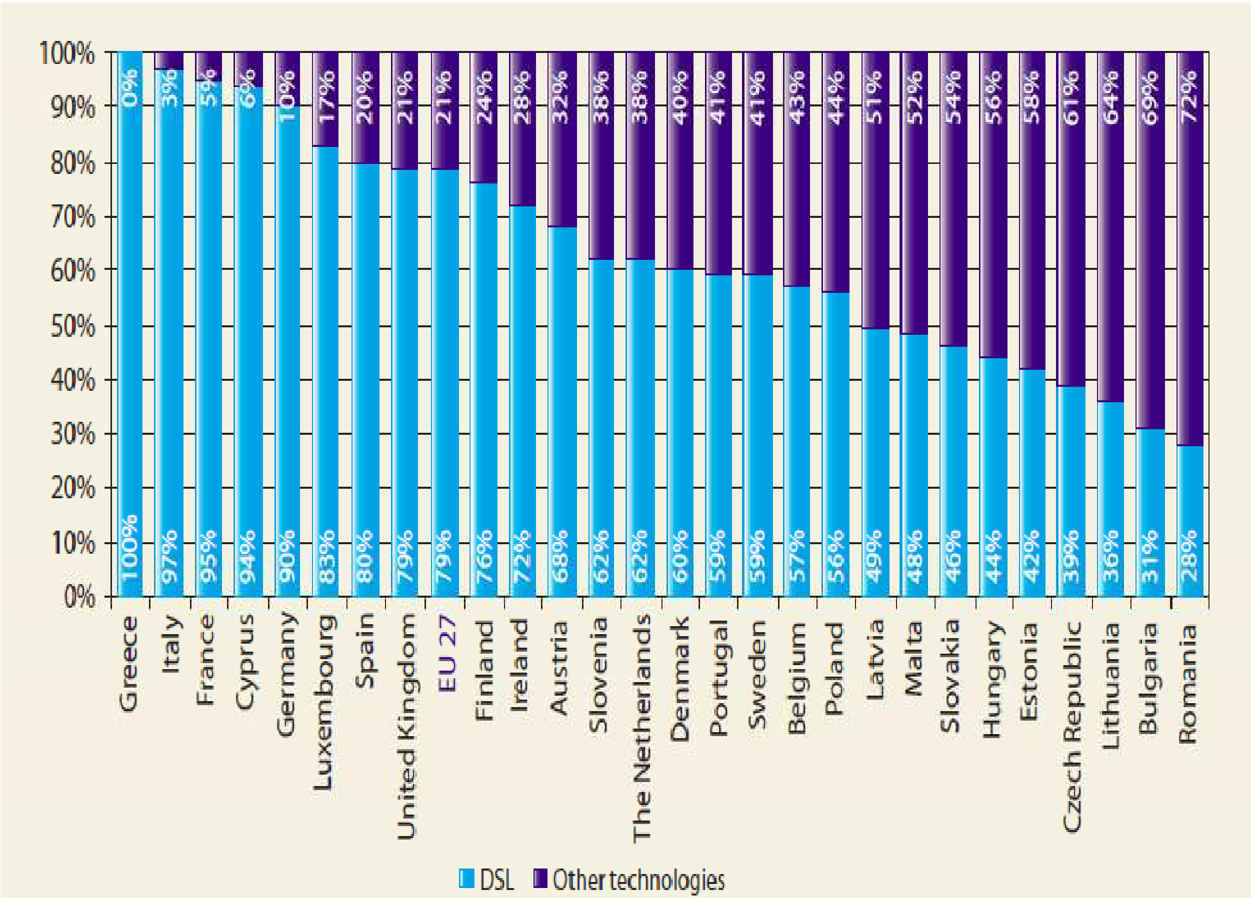
Chart 6: Evolution of Broadband Lines by Technology



Source: EETT [3.] (based on licensed providers' data)

Finally, the level of broadband lines of other technologies remains very low at a percentage of 0.5% that is by far the lowest among EU member states (Chart 7). DSL still remains the main broadband service in Greece.

Chart 7: Distribution of Broadband Lines by Technology, December 2009.

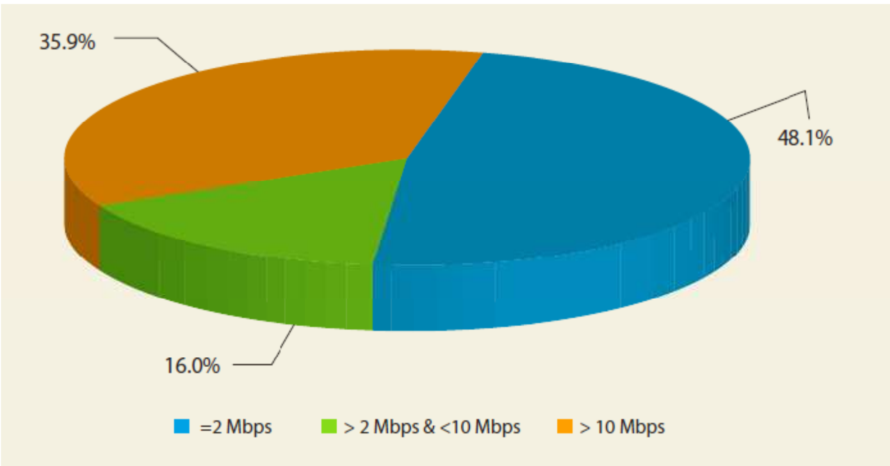


Source: 15th European Commission Implementation Report.

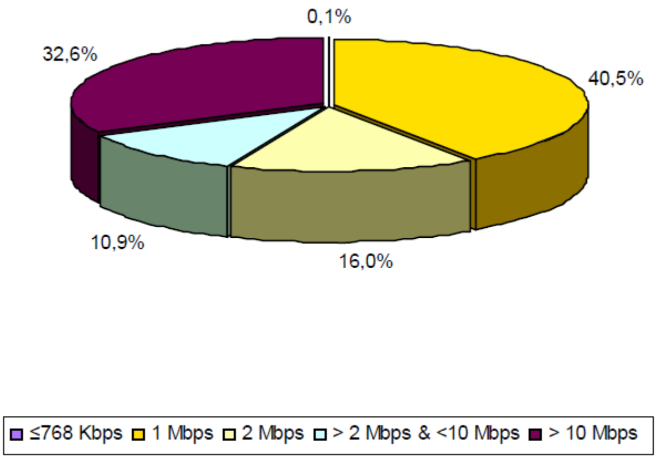
1.5.4 Speeds of Broadband Lines

Chart 8 presents the distribution of all broadband lines by access speed. All broadband lines now operate at speeds equal to or more than 2 Mbps (download). 16% of lines operate at speeds ranging from 2 up to 10Mbps (download), whereas 36% of lines operate at speeds higher than 10 Mbps. The remaining 48% operate at 2 Mbps (download). The phenomenal increase in the amount of data in the Internet and related networks has caused a similar demand for bandwidth and faster connections speeds. The percentages on 31-12-2008 were 10.9%, 32.6%, and 16%, respectively. From chart 8 we can come to the conclusion that the need for higher speed has led to the elimination of speeds like 768 Kbps and 1 Mbps and the increase of the speed of 2 Mbps from 16% to 48%.

Chart 8: Percentage Distribution of Broadband Lines' Nominal Speeds, December 2009



and, percentage Distribution of Broadband Lines' Nominal Speeds, December 2008

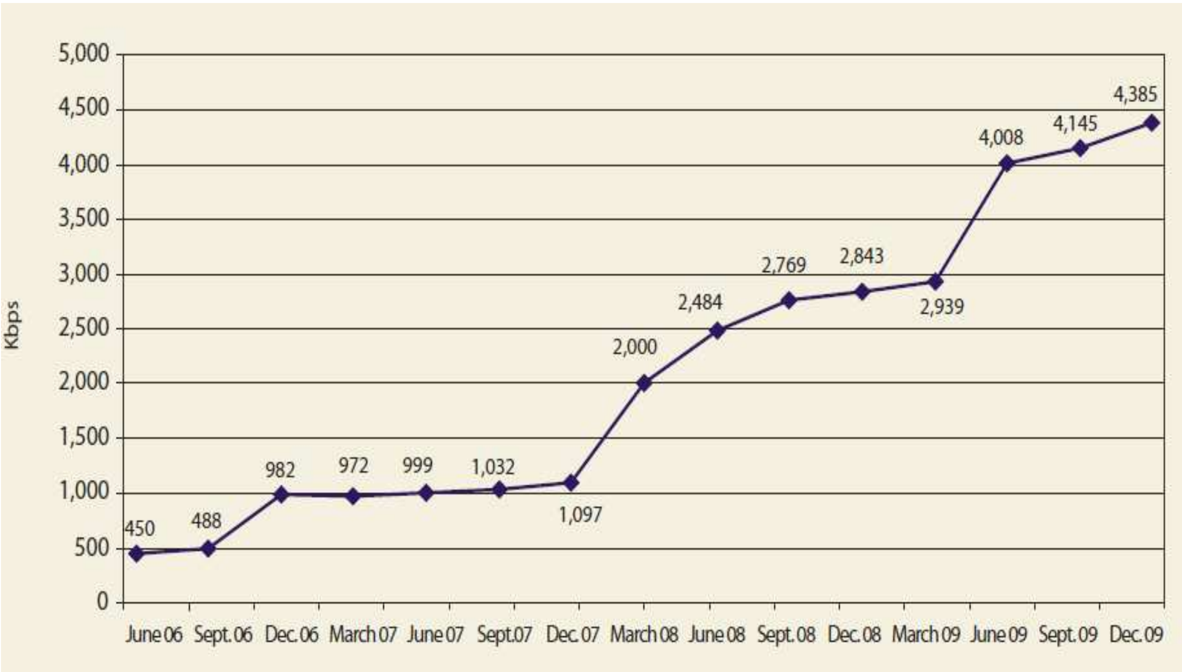


Source: EETT [3.] (based on licensed providers' data)

Last, Chart 9 shows the progress of the average speed of ARYS lines (wholesale and retail lines from the incumbent operator HTO “OTE”) which depicts a continuous rise, reaching a speed of 4.385 Mbps on 31-12-2009 as compared to 2.843 Mbps on 31-12-2008.

The increase from 1.097 Mbps to 2.000 Mbps from December 2007 to March 2008 is due to the liberation of the ADSL market from EETT with Local Loop Unbundling – LLU, which has forced the incumbent operator HTO “OTE” to rise up its speed to keep up with the Market needs from the relevant Internet Service Providers in Greece (Forthnet, HOL, etc.)

Chart 9: Evolution of Average Nominal Access of ARYS Lines

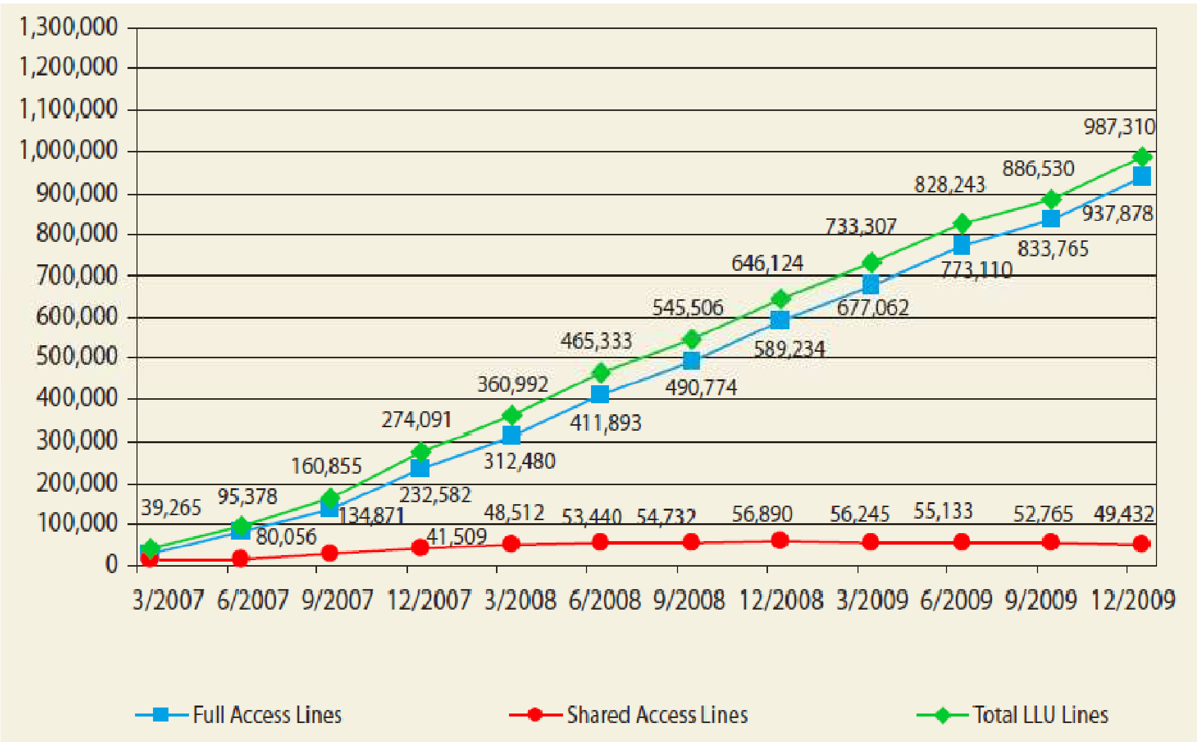


Source: EETT (based on licensed providers’ data).

1.5.5 Local Loop Unbundling

ASDL access via LLU (Chart 10) reached the number of 987,310 lines on 31-12-2009 compared to 646,124 on 31-12-2008 (increase by 53%). This increase is entirely due to full access lines, given that shared access lines are relatively stable, thus presenting a decrease by 13% for 2009. The average monthly access cost for a fully unbundled loop in Greece amounted to 9.14 Euros compared to 9.75 Euros of the European average, making Greece the 8th cheapest country in the EU (Chart 12). The relevant price for 2008 was 9.65 Euros (decrease by 5%). Respectively, the average monthly access cost for shared access amounted to 3.24 Euros compared to 3.53 Euros of the European average, making Greece the 10th cheapest country in the EU (Chart 13). The relevant price for 2008 was 3.39 Euros (decrease by 4%).

Chart 10: Evolution of LLU Lines



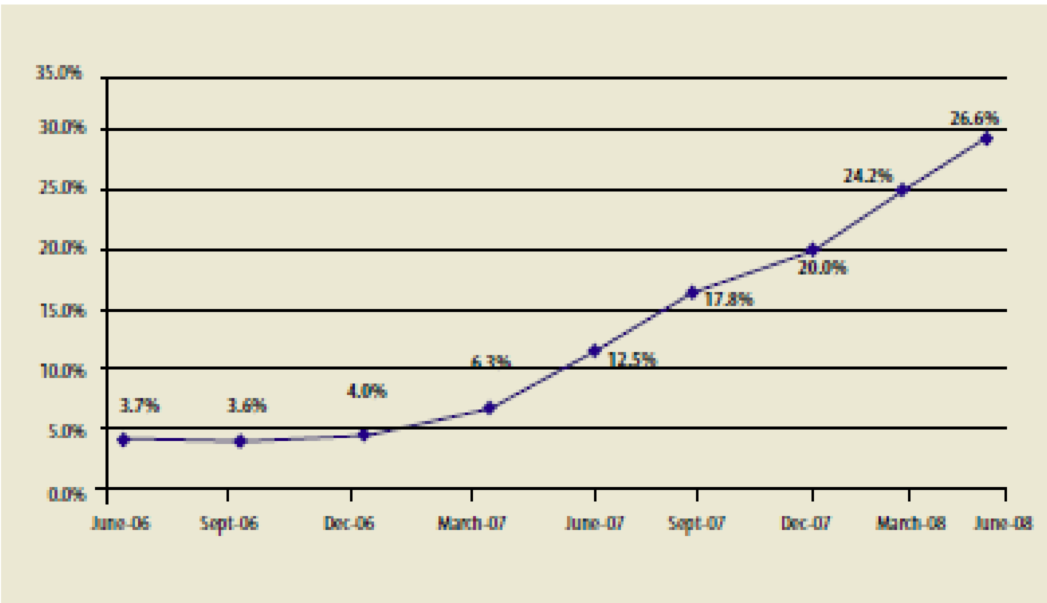
Source: EETT [3.] (based on licensed providers' data).

It is noted that the regulative and supervisory intervention of EETT played a decisive role in the progressive course of LLU, since the modification of RUO, legislated by Decision 129/45/4-4-200.

The year 2007 was a landmark year for the broadband progress in Greece. The broadband connections exceeded 1,000,000 at the end of the year (population penetration rate 9.1%). At the same time Local Loop Unbundling (LLU) demonstrated a rapid growth

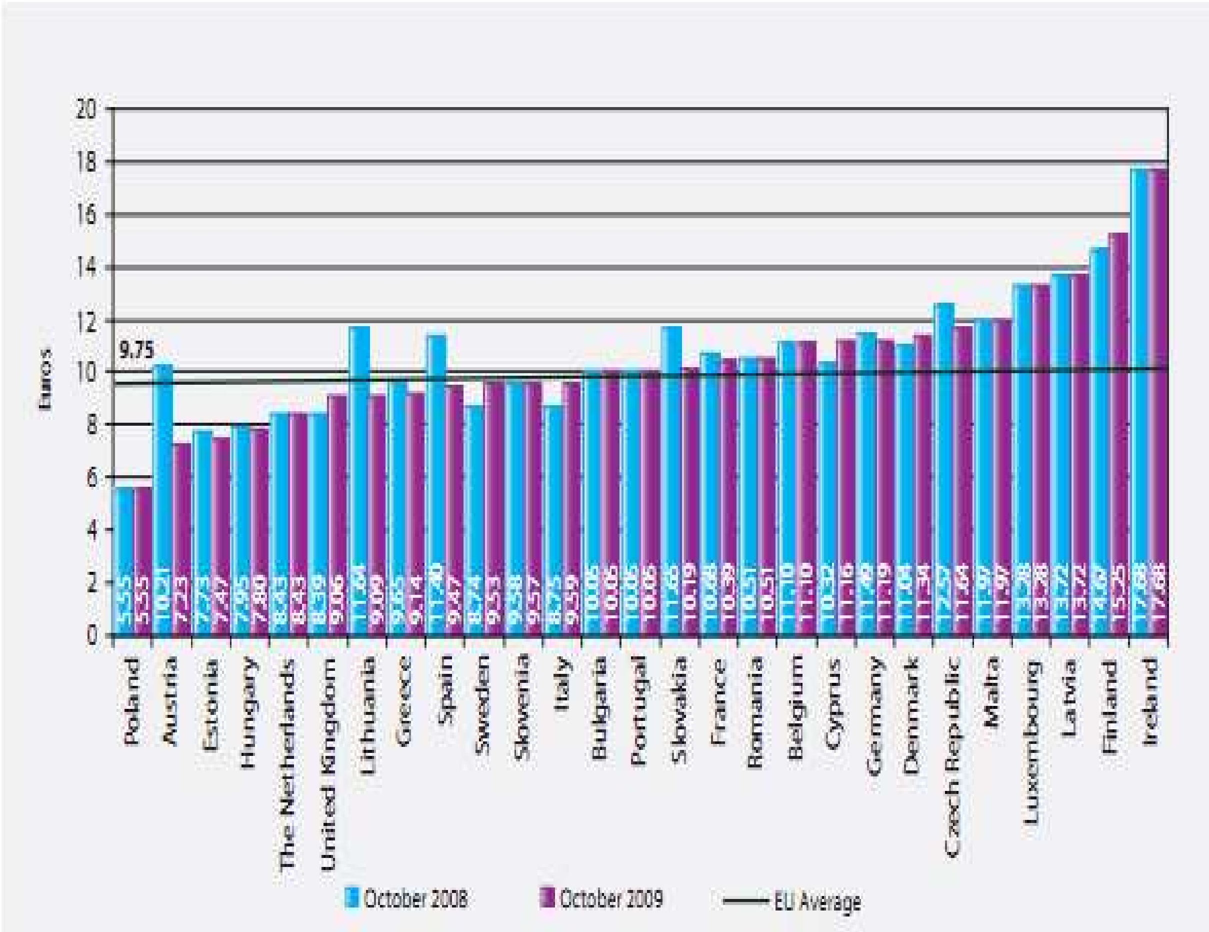
It is obvious that the exploitation of LLU has offered the ability to alternative providers to promote a series of service packages to the market, which combine broadband access to the Internet with telephony services and in some cases television or video-on-demand services over the Internet. Moreover, contrary to previous years, alternative providers based their development mainly on the use of LLU and much less to other wholesale broadband access products. This fact suggests the transition of many providers to higher levels on the investment scale, as they were now able to develop, offer and support new innovative products for Greek standards, such as double-play, triple-play, etc., offering a wide range of options to the Greek consumer in competitive prices.

Chart 11: Development of LLU Lines as a Percentage % of Broandband Lines



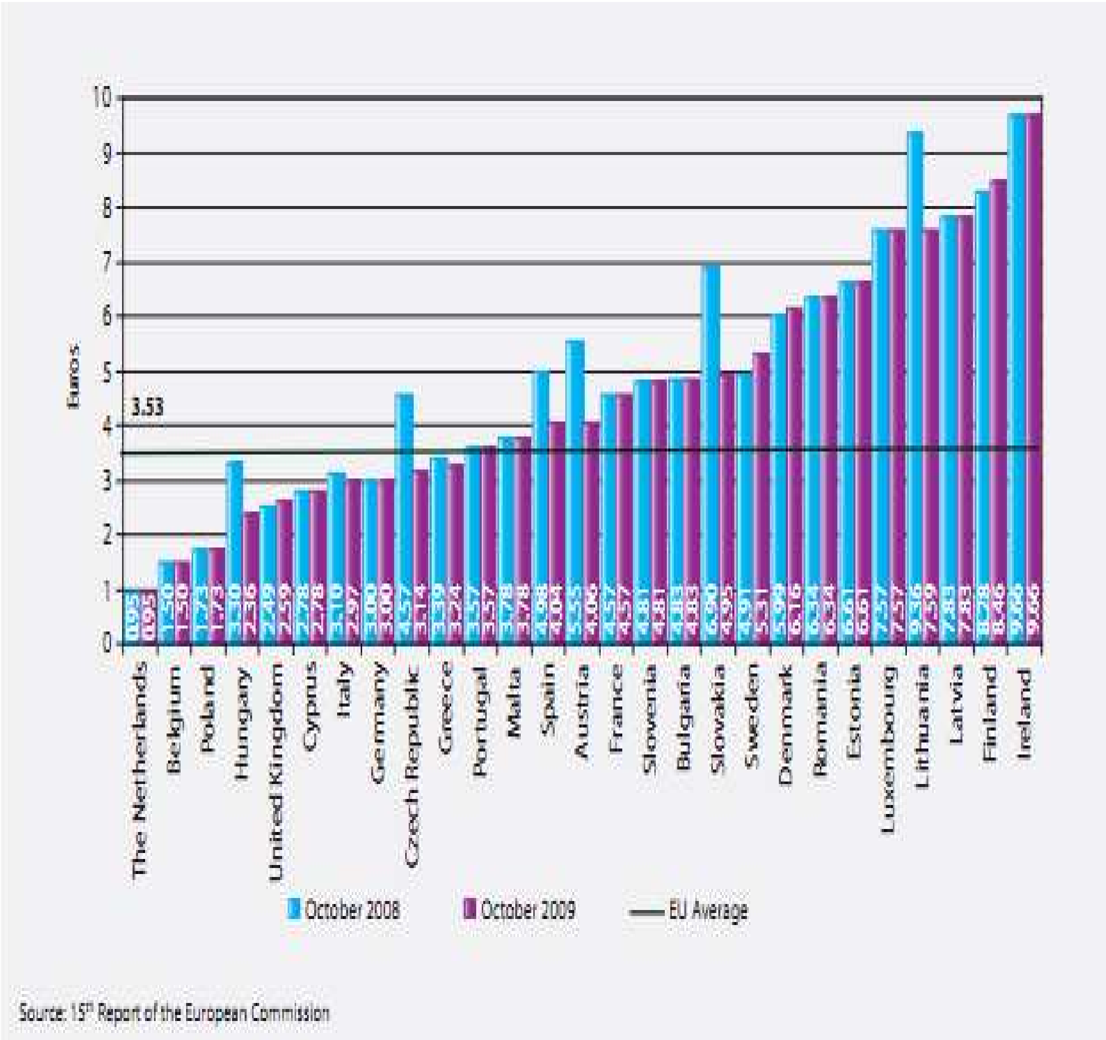
Source: EETT [3.] (based on licensed providers' data).

Chart 12: Monthly Average Total Cost per Full Access LLU Line



Source: 15th European Commission Implementation Report.

Chart 13: Monthly Average Total Cost per Shared Access LLU Line



Source: 15th European Commission Implementation Report.

1.6 Basic Internet Service Providers in Greece

1.6.1 Hellenic Telecommunications Organization (HTO 'OTE')

Hellenic Telecommunications Organization **[6.]** (HTO – "OTE") is the largest telecommunications provider in Greece, and together with its subsidiaries forms one of the leading telecom groups in Southeastern Europe.
HTO is among the five largest listed companies, with respect to capitalization, in the Athens Stock Exchange and is also listed in the London (LSE) Stock Exchange.
Following an agreement between the Greek Government and Deutsche Telekom, since 5th November 2008, each held 25% plus one share in HTO' s share capital.
Since 31st July 2009, following the sale of a further 5% of HTO share capital by the Greek State to Deutsche Telekom, the Greek State holds 20% and Deutsche Telekom 30%.
The HTO Group offers a full range of products and services, from broadband services, fixed and mobile telephony, to high-speed data communications and leased lines services.

The rapid expansion of broadband penetration along with increased demand for data transfer require the migration from TDM and copper infrastructure networks, designed for voice services, to IP technology which carries multimedia traffic. At the same time, increasing demand for access creates the need for a relevant adjustment of transmission systems and of the architecture of the backbone network. Within this context, and acknowledging its critical role in the rapid development and expansion of broadband penetration, HTO continues to invest in network platforms, services platforms and support systems. Ongoing efforts involve infrastructure investments across the country and are aimed at enabling migration to an advanced, high-capacity network, which will support a wide range of broadband services.

Access Networks

ADSL

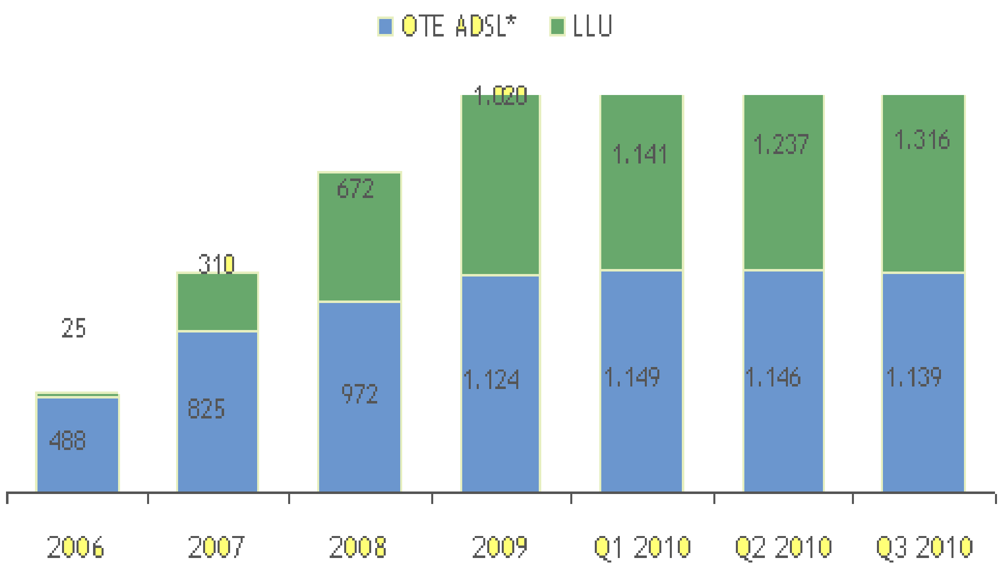
- Constantly expanding our network across the country – including areas of low population density – in order to enable citizens to use broadband services
- Over 1,000,000 ADSL subscribers
- ADSL speeds 2, 8 and 24 Mbps
- Conn-x TV Digital TV Services through broadband access (IPTV) at 2,8,24 Mbps

New Technologies

WiMAX: pilot test for wireless broadband access
WiFi: HTO WiFi Hotspots give allow customers wireless access to the Internet via their laptops or PDAs
(Data as of 31/03/2009).

Fixed Line in Greece-Broadband Services

Placing special emphasis on the development and promotion of broadband services, HTO offers high ADSL access speed packages through its broadband brand “conn-x”. The company has also focused on reducing “conn-x” services tariff plans and on developing its infrastructure further by increasing ADSL points of presence in its telecommunications network. In addition, HTO has introduced new types of voice services in its broadband Internet packages, aiming to respond to growing market demands for specialized bundled products both for residential as well as business customers.



[7.]
** Retail & Wholesale*

1.6.2 Hellas online (HOL)

Hellas online (HOL) **[8.]** is one of the leading providers of fixed-line telephony services in Greece, providing a range of voice and internet access services. HOL owns and operates a large core backbone network throughout continental Greece and through its points of presence (PoPs) it offers significant population coverage of the two largest cities in Greece, Athens and Thessaloniki. HOL has provided internet access services in Greece since 1993, having been one of first internet service providers (ISPs) in the country. HOL has evolved from an ISP, offering primarily internet access services, to a fixed-line telecommunications services provider offering a broad range of retail, business and wholesale services.

Hellas online is one of the leading Greek fixed-line telephony services providers based in Athens. Hellas online (also known as "hol") is member of the Intracom Holdings group since 2006, is one of the first Internet providers in Greece to offer public dial-up Internet services, and has since evolved from an ISP, offering primarily internet access services, to a fixed-line telecommunications services provider offering a broad range of retail, business and wholesale services. It offers the highest latencies in online gaming amongst all Greek broadband internet providers.

In June 2008, Hellas online merged with Athens Stock Exchange - listed company Umbrian, and became enlisted under the name Hellas online (HOL)

The Network HOL [9.] owns and operates a fibre optic network of approximately 3,278 kilometers as at August 31, 2008. Its core backbone network is the second largest network in Greece after that of OTE, the incumbent operator. Through its points of presence (PoPs) comprising physical co-location in unbundled local loops (LLUs) HOL offers extensive population coverage in the metropolitan areas of the two largest cities in Greece, Athens (over 80%) and Thessaloniki (over 70%), and significant coverage of population in the rest of Greece. HOL's extensive proprietary fibre optic network connects the three major Greek cities of Athens, Thessaloniki and Patra and covers significant parts of the most densely populated areas of Greece (Larisa, Karditsa, Trikala, Volos, Lamia, Thiva, Livadia and Chalkida). HOL's network provides high-capacity connection between its data centers and sites, thus allowing HOL to backhaul high bandwidth cost-effectively to its unbundled local loops, without having to lease capacity from OTE, while in certain cases, enabling HOL to lease its own spare capacity to other Greek or international telecommunications operators.

Products and Services of HOL

In addition to its historical narrowband internet access services, HOL has expanded its services to its retail customers to include offering:

- bundled fixed-line telephony and internet access services
- single-play services (broadband internet access over shared LLU); and
- double-play services (broadband internet access and fixed-line telephony) over full LLU as part of its "DoublePlay" product, and voice-only services over LLU.

HOL offers telecommunications services and solutions to its business customers, including:

- leased line SDH and metro Ethernet
- Virtual Private networks (VPNs)
- web hosting
- wholesale services to other national and international telecommunications operators.

1.6.3 Forthnet

***Forthnet* [10.]** is the largest private broadband and satellite service provider in Greece. Its primary objective is to remain close to its customers on a continuous basis and to develop tailor made solutions. This is why the company makes sure that it invests in new technologies and infrastructure and develops integrated telecommunication proposals and solutions, which are addressed to both residential and business consumers.
Within this framework, in the past years Forthnet has invested hundreds of millions of Euros in order to develop its own infrastructure throughout Greece; this includes a private fibre optics network and a Wireless Local Access Network. Furthermore, the company owns fibre optic submarine cable circuits and ensures continuous upgrading of its international Internet interconnection speed.

The development of a very extensive national network of specialized broadband stores constitutes an important investment for the company; the aim of this Forthnet-branded network is to provide good quality personalized service to consumers throughout Greece.
Forthnet is the company that introduced the Internet to Greece and it currently offers a wide range of broadband services with an emphasis on the Internet and fixed telephony. Moreover, in August 2008, after acquiring NetMed N.V. and Intervision (Services) B.V, the company entered the pay TV sector dynamically.
Forthnet's rich portfolio of services covers all the telecommunication needs of households, small businesses and large organizations.
As regards residential consumers, the company offers a very wide range of Internet access and telephony services. Furthermore, aiming at providing broadband access everywhere, Forthnet is developing the largest network of wireless access points throughout Greece.

Everybody can enjoy wireless broadband access through the Forthnet Hotspot network, even far from home or the office.

As regards corporate services, Forthnet supports modern businesses by offering good quality Internet access solutions, corporate networks (MPLS VPN), interconnection of remote points of presence (leased lines), fixed telephony, computer system and application hosting, and also advanced surveillance, management & maintenance services, together with technical support for such services (Managed Services).

Home Services

- Forthnet 2play

Enjoy unlimited calls to all Greek fixed numbers, unlimited calls to fixed numbers in 43 countries, 60 minutes free calling time to all national mobiles and unlimited broadband internet up to 24Mbps.

- Forthnet ADSL

Enjoy unlimited broadband ADSL, free WiFi access at all Forthnet HotSpot and 50 sms/ month for free.

- Forthnet Telephony

Enjoy unlimited calls to all Greek fixed numbers, unlimited calls to fixed numbers in 43 countries and 60 minutes free calling time to all national mobiles.

1.7 Recent developments in Telecommunications and the need for analyzing the demand for broadband Services

In our days we have a lot of information in many activities and function of the economy is microeconomic and macroeconomic level.

Many economists have analyzed the impact of “Moore’s law” which claims that computer processor power (measured by the number of gates on a single processor chip) doubles every 18 months, leading to drastic evolution in the price of processing power (measured in MIPS).

What economics, as many in industry, have missed, is the bandwidth growth “law”: “The total bandwidth of communication systems will triple every year for the next 25 years”. This “law” is a consensus opinion not necessarily first established by thorough analysis.

Telecommunications are over time the basic domain for the economical development. The rapidly development of the past, with innovations such as mobile telephony and the Internet have led to a fundamental change into the telecommunication industry and market.

Understanding the process of Internet adoption and diffusion as well as the main determinants of cross-country differences in this process seems to be of particular interest since, as it has long been acknowledged, the Internet is a key tool of economic development **(Kenny, 2003; Roller & Waverman, 2001; Sanchez-Robles, 1998).**

Luis Andres David Cuberes Mame Diouf Tomas Serebrisky [11.] analyze the process of Internet diffusion across the world using a panel of 214 countries during the period 1990–2004. Countries are classified as low- or high- income and it is shown that the diffusion process is characterized by a different S-shaped curve in each group. It shows that network effects are crucial to explain this process. One important finding is that the degree of competition in the provision of the Internet contributes positively to its diffusion

Internet adoption has brought to consumers, Internet adoption has had a significant impact in terms of cost savings for the corporate sector (**Varian et al. (2002)**) or in terms of information diffusion among the academic world.

Fildes and Kumar (2002) [12.] successful modeling of the constantly changing telecommunications market has been limited due the demise of the monopolistic national suppliers on the one hand and rapid developments of competitive new technologies on the other. They argue the accuracy of econometric approach diffusion models across the wide range of telecommunications applications as they require long data sets which are not available as a result of the short life cycle of the respective services.

Chinn and Fairlie (2007), they use panel data from 161 countries for the years 1999–2001 to identify the determinants of cross-country disparities in the usage of personal computers and the Internet. Although income differences play a major role in explaining the digital divide, they show that there are other important determinants such as regulatory quality and the level of infrastructure.

Guillen and Suarez (2001, 2005), focus on the effect of economic, political, and sociological factors on Internet usage.

The natural monopolist that were in the market for decades are going to be demolished fully and there are created the right bases for the creation of many competitive companies for the supply of telecommunication service.

Inmaculada Cava-Ferreruela, Antonio Alabau-Munoz [13.] provide some insights into the effectiveness of different policy choices to promote broadband. They explore the factors influencing broadband supply, demand, and adoption. The results suggest that technological competition and the low cost of deploying infrastructures on the one hand and the predisposition to use new technologies on the other, appear to be the key drivers for broadband supply and demand, respectively.

In most countries, the state monopolists providing telecommunication services have been privatized, fully or part. Special independent regulatory authorities have been created, new companies have been licensed, and there have been introduced new regulations for the interconnection of competitive companies and markets.

Harold Ware Christian M Dippon [15.] explore the effects of network unbundling in telecommunications. It includes discussions of the basic economics of unbundling; the competitive effects of unbundling on voice services in the US and broadband in the US and the European Union; and unbundling policy in a world of convergence. Mandatory unbundling can delay facilities-based entry and reduce network investment, particularly if unbundled input prices are set too low. Excessive prices for essential network elements could hamper competitive entry. The results suggest that when relevant demand and supply determinants are included in the analysis, the association between mandatory unbundling and increased broadband penetration is not statistically significant.

Also there has been a change in the regulations which are related with the billing and the provision of telecommunication service into final consumers. The main point of all these changes was the introduction of competition forces in market so as to reduce prices, to increase productivity and to make better the Quality of Services (QoS)[1].

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[1] **QoS** (Quality of Service) refers to a broad collection of networking technologies and techniques. The goal of QoS is to provide guarantees on the ability of a network to deliver predictable results. Elements of network performance within the scope of QoS often include availability (uptime), bandwidth (throughput), latency (delay), and error rate.

David SRAER [14.] measures the extent to which Local Loop Unbundling regulations in the broadband industry affect the demand for high-speed Internet. Because the Telecommunication industry is on the brink of a major wave of investments in new “Fiber to the Home" networks, understanding the relative benefits of service vs. infrastructure based-competition is important. It is shown that unbundling by at least one operator causes a large, significant shift in penetration. It is also find a large part of broadband demand following Local Loop unbundling cannot be attributed to lower prices, indicating that quality increase and/or local marketing efforts also plays a crucial role in widening Internet penetration.

The notion of quality of service (QoS) has different dimensions, such as response time, delay, resolution, integrity/security and subjective quality (voice, video, etc.).

Today each user may have physical access to different networks, owned or not by the same or different operators, and which he relies on for diverse services and QoS qualities of service. For all such combinations, different rates would apply, some regulated, some not, and anyway complex billing and payment would be necessary. One way around this is to have operators owner service and access packages, bundling together, say x number of local telephone calls, with y minutes of long distance calls, with z minutes of mobile connections, with t Internet packets sent or received. Research is needed, linking user behaviors, with costing and profit margin issues, to define innovative subscription packages. (**L F Pau) [16.].**

The main purpose of the regulatory authority is to make the best from the side of the consumer.

One political or regulatory concern is, in today’s model, to mandate equal and universal access to some key services. The term “universal” is linked to location and economic resources. According to Article of the EU interconnection directive, universal service means a defined minimum set of services of specified quality which is available to all users, independent of their geographical location, and, in the light of specific national conditions, at an affordable price. In the days of monopoly operators, this was achieved by letting other subscribers carry the incremental investments and costs. In a deregulated framework, competing operators have a hard time supporting the subsidies to specific locations or user groups, while new operators emerge catering to those groups, but at higher costs or lower service levels. Anyway, the issue is just at its beginnings as the policy is still enforced at the operator level, and not attacked from the user-driven perspective, i.e. allow for access to at least one of the networks irrespective of the technology used.

The purpose of USO is (or should be) to provide communications service to those who could not otherwise afford this service when priced at the true market cost of provision.

The principal issue addressed from **James Alleman Paul Rappoport Aniruddha Banerjee [17.]** is, what should be included in the definition of USO. The notion of connectivity, namely, whether a device or network allows communication with the rest of the world should be included in the definition. A corollary is that no single technology (or service) should be provided with a subsidy or generates a subsidy, so as not to tilt the playing field. Broadband connectivity is critical to infrastructure in the information age for economic growth and development.

The study and especially the forecasting of the demand for broadband networks and services id the main subject for the evolution of the telecommunication from the point of the provider as well as from the side of the regulatory.

2. Chapter 2

2.1 Literature Review

2.1.1 Approaches in Europe

A significant number of efforts to determine the market size and estimate the demand for various types of telecommunications services can be found in the literature especially for developed markets.

The importance of demand forecast for telecommunications services for engineers and marketers is highlighted in telecommunications literature. **Rappoport et al. (2002) [18.]** question of Willingness To Pay (WTP) and consider it as the underlying basis on any demand curve.

Alleman and Rappoport (2007) [19.] differentiate demand for access from demand for content and raise discussion in a wide perspective, approaching the demand for telecommunications services as derived from the consumer’s ability and willingness to pay for them in relation to other basic needs such as food, shelter, health care, etc. considering the increase rate of subscribers in services that require broadband access in association with the respective modification of ICT expenditure share of Gross Domestic Product (GDP), they highlight the importance of the last kilometer affair.

Rappoport et al. (2003) [20.] gives serious consideration for the characteristics of the end users (age, income, education, ethnicity, rural/non rural resident) and describe two models. The discriminant model which correlates broadband demand with socioeconomic and demographic characteristics and the users’ specific activity and the discrete choice model which is based on access price, value of time and opportunity cost in association with the self-selected discrete choice of broadband or dial-up access. Main conclusion is that the so-called digital divide is more likely to be a geographic phenomenon rather than a socioeconomic one, so broadband services availability is likely to fall behind in rural areas without substantial supply subsidy provided by the state. Concerning rural/urban differences in particular, a research related to the provision and use of broadband in the EU countries was conducted under European Committee’s support.

Trkman et al. (2008) [21.] identify the latent variables that influence broadband development, namely factors that cannot be observed directly. Pairs of variables such as GDP, price of broadband connection, population density, etc. are used. The first factor is connected to economic variables (income, broadband service price, etc.), the second one is correlated with the use of specific services (e-commerce, e-transactions, etc.) and the third one is connected with indicators which show the state of ICT environment within a country (PC access, education level, number of phones, etc.). The study finally indicates direct actions by local governments and various stakeholders to stimulate broadband demand (e.g. effective competition by promoting and giving emphasis on local loop unbundling, liberalization of infrastructure and network services, public–private partnerships, tax incentives for investments, etc.).

Ida and Kuroda (2006) [22.] explore broadband market in Japan considering the four available alternative modes of connection (ISDN, ADSL, Cable TV and Fiber To The Home (FTTH). ADSL service is less elastic than the other three services, implying that market of ADSL is independent of the others. Furthermore, because of the fact that the ADSL constitutes almost the three quarters of the whole market, three different speed categories within the ADSL market (low, medium and high) are scrutinized. It is concluded that demand for medium-speed ADSL is less sensitive to price changes than the other two categories. However, as broadband evolution continues medium-speed users are likely to switch to high-speed rendering ADSL a substitute of FTTH.

Kenneth Flamma, Anindya Chaudhuri (2007) [23.] extends the analysis of the relative impacts of socioeconomic factors on households' decision to subscribe to dialup Internet access [**Chaudhuri, A., Flamm, K., & Horrigan, J. (2005)**]. It is found that the decision to purchase any access at all, and the decision to upgrade to broadband, may be affected differently by various socioeconomic factors. The own-price elasticity of broadband demand is statistically significant and has a substantial coefficient value. The cross-price sensitivity of broadband demand with respect to dialup price is also statistically significant, and supports the notion of the two services being substitutes. Observed consumer selection of broadband services may be entirely absent in many geographical areas not because the residents are not interested, but because service providers find the economics of small and sparsely populated markets unattractive. **Chaudhuri, Flamm, and Horrigan (2005*)*** analyzed price, geography, and the demand for dialup Internet access. They also considered a simple model for broadband access, but the results were inconclusive because of problems with the homogeneity assumptions embedded within an ordered logit modeling framework.

Price though theoretically the most interesting determinant of Internet service choice is also the least explored and understood. Price is important both as a key to understanding the market and as an instrument for changing it. When comparing two markets, ceteris paribus, lower prices are usually associated with more competitive market structures. Were the own-price elasticity of broadband proven to be high, price could also be viewed as a potential instrument shaping broadband penetration, influenced through regulation, or even through subsidies.

Evidence is found in Kenneth Flamma, Anindya Chaudhuri (2007) that broadband price is indeed a statistically significant driver of broadband demand. While demand is relatively inelastic, the coefficient is high enough to indicate a not-inconsequential practical impact. If this finding is supported by further research, then broadband price declines (and dialup price increases!) may well have played an important supporting role in explaining some portion of recent increases in broadband penetration rates. On the other hand, after controlling for price, the authors find that other non-price factors also seem to affect dialup and broadband demand rather differently. They reject the hypothesis that effects on choice of low- and high-speed service are the same for marital and student status, gender and metropolitan location. One interesting finding is the stark contrast of urban and suburban households with their rural counterparts.

Besides econometric studies of Internet access choice by Goolsbee (2000), Rappoport, Kridel, Taylor, Duffy-Deno, and Alleman (2002), and Varian (2002), which consider the trade-off between access speed and subscription price, there is limited publicly available research examining the service attributes preferred by consumers and their willingness-to-pay (WTP), **Scott J. Savage, Donald Waldman [24.]** examine residential demand for broadband Internet access. Survey data are used to investigate consumer awareness of Internet access service, profile residential Internet access and use, and gain insight into how important always-on connectivity, price, speed, installation, and reliability attributes are in the household choice of service. Empirical results provide information for the design, pricing and marketing of more effective Internet access services, and may also prove useful for policy makers debating the ‘‘digital divide’’ and policies that promote access to the Internet, e-commerce, e-government, e-health, and educational opportunities. Savage and Waldman (2002) extend the traditional labor–leisure choice model to include the benefits–costs of Internet access. Data are used to investigate consumer awareness of high-speed Internet access, profile residential Internet access and use, and gain insight into how important ‘‘always-on’’ connectivity, price, speed, installation, and reliability attributes are in a household’s choice of service. Analysis of survey data suggests that household awareness of high-speed service availability is relatively high for cable modem and DSL technology. Preference for high-speed access is apparent among households with a higher income, a college education and multiple PCs.

Yuji Akematsu [25.] analyzes the factors promoting the ADSL market by using the data of its subscribers. Akematsu utilizes panel data of monthly subscribers of four ADSL carriers to overcome the problem of shortage of data, the ADSL market has been an oligopoly.

Gregory Rosston Scott J Savage Donald M. Waldman [26.] determine consumer valuations of different aspects of broadband Internet service. They estimate household demand for broadband Internet service. The report combines household data, obtained from choices in a real market and an experimental setting, with a discrete-choice model to estimate the marginal willingness-to-pay (WTP) for improvements in eight Internet service characteristics.

- Price per month for Internet service (COST)
- Time it takes to download and upload information (SPEED).
- Reliability of the connection to the Internet (RELIABILITY).

The empirical results show that reliability and speed are important characteristics of Internet service.

The latter finding indicates that very fast Internet service is not worth much more to households than fast service. Willingness-to-pay for speed increases with education, income and online experience, and decreases with age. Rural households value connection speed more per month than urban households. It is found that valuations for Internet increase substantially with experience.

It is difficult to estimate demand for broadband service, and more importantly for specific characteristics of broadband service with data currently available. For example, while there is information about subscription rates to Internet access, pricing and plan choice are not generally available publicly.

Broadband adoption in rural areas

Victor Glass - Stela K. Stefanova [27.] examine the factors that will encourage broadband adoption in rural areas. They found that low density, high cost markets decrease the ability of the telecommunication service providers to offer DSL, but other factors also play a role. Demand for broadband has become more inelastic over time, marginal increases in speed alone have lost their appeal to customers, and the inclusion of video in a broadband package improves broadband take rates and willingness to pay. Small income elasticities reinforce our finding that broadband has become a necessity. It is shown that price subsidies may not be effective in providing a large boost in demand, but policies that lower the cost of providing video may stimulate broadband adoption indirectly if the savings lead to more affordable bundled communications multimedia packages that users want.

Broadband platforms

There are several physical networks over which broadband services can be offered to end-users. Digital Subscriber Line (DSL) is the platform for broadband access technology via the upgraded traditional fixed telephone network, the Public Switched Telephone Network (PSTN).

The other main platform for broadband services is cable modem technology, which provides broadband access over cable television networks. In order to provide broadband services, these cable television networks need to be upgraded to make two-way traffic (uploading and downloading) possible.

Besides DSL and cable, there are newer platforms able to provide broadband access. These upcoming platforms include optical fibre and wireless technologies, such as third-Generation (3G) mobile telecommunications or WiMax. In practice, however, they still play a relatively minor role in most countries.

Jan Bouckaert, Theon van Dijk, Frank Verboven [28.] empirically investigate to what extent different forms of regulated competition explain of the substantial differences between OECD countries from the evolution of broadband penetration.

Felix Hoffler [29.] shows that infrastructure competition between DSL and cable TV had a significant and positive impact on the broadband penetration. The two main access technologies for residential broadband products in Europe and in the US are DSL and cable modem. (Cable modem allows for higher transmission rates, which also have more symmetric down- and upload capacities). Both technologies are rolled out first in urban areas, and frequently they are not offered at all in rural areas

2.1.2 Approaches in Greece

Moutafides and Economides [30.], have taken into account regulation issues and the commonly admitted inequality of broadband access availability between urban and rural area, delivering fixed broadband lines to customers in Greece.

There has been made an attempt to estimate empirically the forthcoming demand for broadband lines. Population's income and effective competition are recognized as the strongest determinants of broadband development.

Data are examined in separate for the 13 territories in which Greece is administratively divided in order to observe possible inequalities between different geographic areas and perform correlations with external variables such as income, age, level of education of each territory's population according to data by the National Statistic Service and the Observatory for the Greek Information Society.

Differentiation between territories is explained by socio-demographic characteristics in cases where results are statistically significant. Moreover, an attempt to predict the future demand trend is made in relation to socio-demographic factors, using a time-series model.

They examine correlations that occur between broadband demand and the following factors:

- Education Level and Age. It yields that the level of education plays an important role to the people's decision to buy a broadband access line as it explains covariations based on regression analysis results.
- Income. The population's income in Greece is increasing even at a slow rate, having a positive effect on broadband demand judging by the extremely high value of the correlation coefficient.
- Sex and Age. With regard to the age of men and women.
- Marital status and Age. Regarding the marital status of different age groups.

Results of the study stiffen the already known positive relationship between broadband lines and income variable as they denote an almost perfect association among them. Same with all goods and services in the end, in the effort of estimating broadband demand, it comes down to price and income and more specifically that price relative to the price of basic needs (food, shelter, etc.). As far as level of education is concerned, demand is affected only by low level educated groups as in most cases persons with higher education are users of innovative services anyhow. Sex is a considerable factor as males influence demand more than females, especially in school ages. It is presume that on-line gaming is a key element to the explanation of this phenomenon considering the increasing sales in the gaming machines market. The marital status variable plays quite an important role as singles and widowers/widows have in general more time and money to spend on entertainment (music/ video downloads, Internet gaming, etc.), not excluding the possibility of using broadband lines for educational or tele-work purposes.

Pantelis Koutroumpis [31.], investigates how broadband penetration affects economic growth. A macroeconomic production function with a micro-model for broadband investment is used to estimate the impact of broadband infrastructure and growth. The results indicate a significant causal positive link especially when a critical mass of infrastructure is present.

There has been made an attempt to measure the economic impact of the telecommunications infrastructure on growth and more specifically the effects of broadband infrastructure. The growing numbers of internet subscribers worldwide make this study particularly important. This issue has also received considerable regulatory and public policy attention especially in the developed countries. There are used evidence from 22 OECD countries over 6 years to estimate the impact of broadband infrastructure.

Koutroumpis estimate the effect of broadband infrastructure on growth using a simultaneous equations model. This model endogenizes broadband Investment by incorporating broadband supply, demand and output equations. The system is then jointly estimated with a macroproduction function hence accounting for the simultaneity effects.

This work adds to this emerging field by incorporating a simultaneous approach methodology that endogenises supply, demand and output and provides measurable estimates for impact of the broadband network externalities for the OECD countries.

The results suggest that there are increasing returns to broadband telecommunications investments, which are consistent with the persistence of network effects. What has been seen is that there is evidence of a critical mass phenomenon in broadband infrastructure investments.

Michael Demoussis, Nicholas Giannakopoulos [32.], investigate the ownership dynamics of home computers in Greece. The probability of ownership is influenced by observed household characteristics (e.g., age, education, family composition, income and familiarity with technologically advanced durables). Greater diffusion of information and communication technologies (ICTs) is expected to increase the efficiency of ongoing development policies and contribute in the realization of faster economic growth. A major facet of ICTs diffusion concerns home computers.

Observed household heterogeneity does influence the probability of home-computer ownership in any given year. Observed heterogeneity concerns household income, age and education of the husband and wife of the household, number and age of children and the household's predisposition towards technologically advanced durables. In the same context, home computer ownership appears to be affected by the density of installed home computers in the area where the household is situated, a finding that suggests the presence of direct network effects and/or local learning spillovers.

The demographic and economic situation of Greek households (age, education, family composition, income) is not expected to drastically change in the foreseeable future. Therefore, the effect of gradual changes in observed correlates on home computer ownership is expected to be modest.

The main implications are the process of narrowing the digital divide between Greece and its E.U. partners will take some time, much longer than it is usually thought and given the existing differences in ownership rates within Greece, diffusion of home computers could reach saturation levels while a significant portion of households abstains **(Schimtt and Wadsworth, 2002) [33.].**

2.1.3 The case of Greece

Greece has lagged behind on broadband networks investments, as a result of manifold reasons as limited terrestrial infrastructure, public ownership of the main vendor, disputed telecommunication policy and late abolition of monopoly in telecoms.

National Regulator Authority (NRA) in the case of Greece the National Committee Of Telecommunications and Post Office (EETT) was established in order to supervise liberalized telecommunications market. However, Greece was the last member of the EU-15 community to incorporate into its legislation the liberalization of the telecommunications market that is to grant to companies other than the state-owned main operator (Hellenic Telecommunications Organization, HTO, ‘OTE’) the right to provide telecommunication services.

According to this directive, the company with significant market power or the biggest market share (HTO in Greece at that time) was compelled to provide universal service, that is ensure that all citizens within Greek territory would have access to a phone line. More importantly, because of the fact that such a company could actually dominate the market and in order to avoid strong monopoly effects, its tariffs for distinct services had to be cost oriented and finally approved by the regulator. Consequently, for any change to its prices for a variety of services, broadband included, HTO had to submit to the regulator a well justified annotation and was further obliged to provide for each retail service a corresponding wholesale one at lower cost.

Private companies seemed hesitant to invest on new technologies and initially settled on trying to build their own clients by offering the same narrowband services (mainly voice) as the incumbent. They managed to do so by leasing high-capacity circuits from the existing incumbent’s infrastructure with wholesale prices controlled by the regulator and using Voice over IP (VoIP) compression provided voice services at low prices.

LLU was promoted by enforcing HTO to provide the ‘‘last mile’’ to other operators and furthermore, to be bound to maintain it on a monthly fee set and controlled by the regulator. This action encouraged private providers to invest on broadband technology and favored the diffusion of sites where broadband access was available.

Another important issue that Greek market had to face was the big difference in the availability of broadband between urban and rural areas.

Nevertheless, although fixed broadband penetration escalated to 17% in January 2009 and 17% in January 2010 from 2.7% in July 2006, Greece currently ranks 23rd in EU-27 far enough from the EU-27 average, which was 23.9% (European Commission Information Society, July 2009 and Observatory for the Greek Information Society, January 2010).

Considering the massive fiscal crisis in Greece and the cuts in salaries and public investments adopted by the Greek government in order to decrease the State’s budget deficit, the distance between Greece’s and the EU’s average penetration rate, though diminishing during the past 2–3 years, is rather controversial as data are likely to change within year 2010. In any case, it becomes apparent and accepted by all stakeholders that there are yet lots to be done towards the goal of digital convergence. On top of the agenda lies the already proclaimed and alleged to be submitted to public consultation, New Generation Access Networks project according to which, outdoor Cabinets (Fiber to the Cabinet) and buildings (Fiber to the Home) are going to be connected with the Central Office through new, fiber optic cables, providing ultra broadband circuits to end-users.

3. Chapter 3

3.1 Econometric Model

The phenomenal increase in the amount of data in the Internet and related networks has fuelled a similar demand for bandwidth and faster connections speeds, which has driven the development of several technological approaches to provide broadband access to end users. Bandwidth - killer application such as videoconferencing, multimedia, and video on demand (VoD) and the ongoing regulation and privatization of telecommunication networks and the rapid growth of distributed business applications have also contributed to this demand for more and more bandwidth from existing networks. Wavelength – division multiplexing (WDM) and terabit routers have generated a vast switching and fiber capacity for the backbone network, which have enabled the backbone network to facilitate high-speed transmission of traffic flowing through the networks.

First we have **Moutafides and Economides [30.]** which they have taken into account regulation issues and the commonly admitted inequality ***of broadband access availability between urban and rural area, delivering fixed broadband lines to customers in Greece.***
Using time-series analysis and examining the correlations between the number of fixed broadband lines and specific demographic factors for the past three years (mid 2006–mid 2009), an attempt to estimate empirically the forthcoming demand for broadband lines is conducted. Population's income and effective competition are recognized as the strongest determinants of broadband development.
Data are examined in separate for the 13 territories in which Greece is administratively divided in order to observe possible inequalities between different geographic areas and perform correlations with external variables such as income, age, level of education of each territory's population according to data by the National Statistic Service and the Observatory for the Greek Information Society.
Differentiation between territories is explained by socio-demographic characteristics in cases where results are statistically significant. Moreover, an attempt to predict the future demand trend is made in relation to socio-demographic factors, using a time-series model.
This paper explores the Greek telecommunications market. It endeavors to provide an empirical estimation of the demand for broadband access lines based on a time-series analysis and taking into account that the era of broadband in Greece is still on an early stage in particular with regard to the short history of real competitive environment. It uses data by the National Regulator Authority and the companies that offer broadband services regarding the diffusion of sites (exchange offices) with broadband availability and the number of the corresponding subscribers focusing on how this number fluctuated during the period mid 2006–mid 2009. The only distinction between subscribers is that of having chosen the incumbent or another company (so called alternative operator) for broadband access.

Integrated Services Digital Network (ISDN) is not considered as broadband connection therefore data concern exclusively Asymmetric Digital Subscriber Lines (ADSL) connections, both symmetric and asymmetric, without further analysis to different speed packages as companies offer a variety of choice for download/upload speed.
For the sake of uniformity in data analysis, all DSL connections are considered as broadband independent of the respective download/upload speed. In addition, data are examined in separate for the 13 territories in which Greece is administratively divided in order to observe possible inequalities between different geographic areas and perform correlations with external variables such as income, age, level of education of each territory's population according to data by the National Statistic Service and the Observatory for the Greek Information Society. The 13 territories examined are shown below:

- Eastern Macedonia and Thrace
- Attica
- North Aegean Islands
- Western Greece
- Western Macedonia
- Epirus
- Thessaly
- Ionian Islands
- Central Macedonia
- Crete
- South Aegean Islands
- Peloponnesus
- Central Greece

In Moutafides, Economides paper there is presented the actual number of broadband access lines separately for the incumbent operator (HTO lines) and alternative providers (LLU lines) indicating that competition has a clear positive effect on the demand for broadband lines. This dramatic shift in the supply side, combined with the effective unbundling of the local loop and the continuously improved public awareness, have led to a rapid increase of broadband lines, which escalated from 318,000 in July 2006 to well over 1.8 million in June 2009. Next table presents the actual number of broadband access lines separately for the incumbent operator (HTO lines) and alternative providers (LLU lines) indicating that competition has a clear positive effect on the demand for broadband lines.

Number of broadband lines.

	Jul-06	Sep-06	Dec-06	Mar-07	Jun-07	Sep-07	Dec-07	Mar-08	Jun-08	Sep-08	Dec-08	Mar-09	Jun-09
HTO	307	347	454	576	657	733	733	770	879	897	945	1008	1039
LLU	11	12	18	39	95	161	274	361	465	545	646	738	828
Total	318	359	472	615	752	894	1007	1131	1344	1442	1591	1746	1867

Transforming the table into the next diagram in, we see that demand for Broadband lines by alternative operators and in total follows an almost perfect linear shape, which is rather expected, considering that the market experienced its childhood throughout the last 3 years. Situation is slightly different for the incumbent since the initial sharp increase is followed by the stabilization and the subsequent mild increase of Broadband subscribers, mainly as a result of the absence of competition until the beginning of 2007.

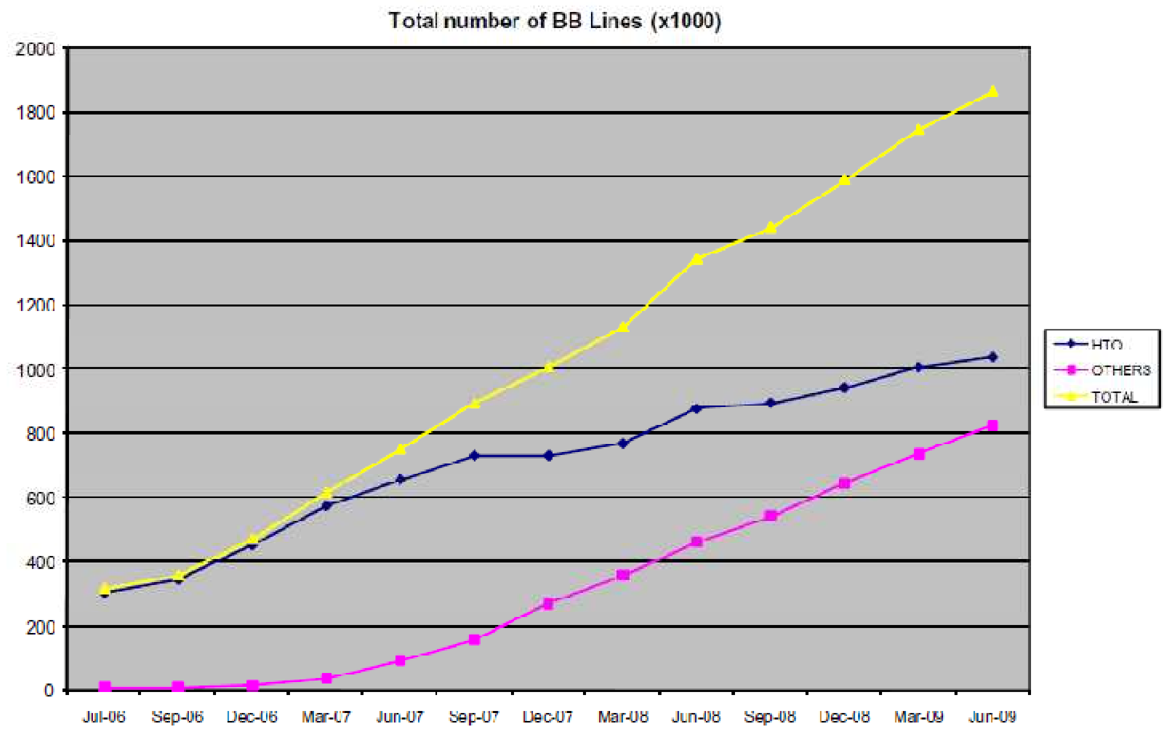


Diagram: Number of broadband lines (HTO and LLU lines).

Henceforth, they try to explain changes in broadband demand as influenced by a number of socio-demographic factors such as education level, age, income, sex and marital status and estimate the demand for broadband for the years to come using a time-series diffusion model which we briefly describe at first.

The model refers to the application of an econometric analysis to time-series data sets. Due to insufficient data regarding broadband subscribers' profile and characteristics, they use a causal method to find correlations between the number of broadband customers and socio-demographic factors, assuming that these correlations will continue to occur in the future (Lutkepohl H., Kratzig M., 2004. Applied Time Series Econometrics, Cambridge University Press).

In statistics, the covariance σ between two variables x, y can be represented as follows:

$$\sigma_{x,y} = E[(x-\mu_x)(y-\mu_y)]$$

For σ = 0, the variables are not correlated. If σ > 0, values above average of x correlate with values above average of y and vice versa, whilst if σ < 0, values above average of x correlate with values below average of y and vice versa. The level of correlation (i.e. how strong variables relate with each other) between variables x and y with expected values μ_x and μ_y and standard deviations σ_x and σ_y is indicated by the correlation coefficient:

$$R_{x,y} = \sigma_{x,y} / \sigma_x \sigma_y$$

Where: $\sigma_x = \sqrt{}E(x-\mu_x)^2$ & $\sigma_y = \sqrt{}E(x-\mu_y)^2$

The correlation coefficient contains covariation characteristics and ranges from -1 to 1. The closer the coefficient is to either -1 or 1, the stronger the correlation (negative or positive, respectively) between the variables.

The computation of the correlation coefficient is usually accompanied by the respective level of significance that is the probability of results being calculated by pure statistical accident. The level of statistical significance p is an estimation of the probability that the result has occurred by statistical accident. Therefore a large value of p represents a small level of statistical significance and vice versa. In the present study a threshold of p = 0,05 is adopted so we consider worthy of evaluation only correlation coefficients between variables for $p \leq 0,05$.

A time series is a set of observations generated sequentially in time (Box, Jenkins, and Reinsel, 1994). If the set is continuous, the time series is said to be continuous. If the set is discrete, the time series is said to be discrete. Let $X(t_1),X(t_2),.., X(t_N)$ be the observations, which are made at times $t_1, t_2,.., t_N$. Discrete time series, which are made between fixed interval T, are written as $\{X_1, X_2,.., X_N\}$, to denote observations made at equidistant time intervals $t_0 + T, t_0 + 2T,.., t_0 + NT$. If t_0 is adopted to be the origin and T the unit of time, one can regard Xt as the observation at time t.

The **cross-correlation function CCF** at delay 'd' is defined as:

$$CCF(\tau) = \int f1(t)f2(t-\tau)dt,$$

Where, τ is the shift of the second variable.

A distributed lags time-series analysis is used to describe the relationship between broadband lines and demographic variables. This is deemed as a specialized technique for examining the relationships between variables that involve some delay (Koyck, 1954). To this modeling approach, we consider demographic factors as independent variables that affect the dependent variable of broadband lines with some lag. The simplest way to describe the relationship between the two would be in a simple linear relationship:

$$N_t = \sum \beta_i * X_{t\ i}$$

In this equation, the value of broadband lines N (the dependent variable) at time t is expressed as a linear function of x (specific socio-demographic characteristic) measured at times t, t - 1, t - 2, etc. Thus, broadband lines variable is a linear function of a specific socio-demographic characteristic which is lagged by 1, 2, etc. time periods. The beta weights (β_i) can be considered slope parameters in this equation. If the weights for the delayed (or lagged) time periods are statistically significant, we can conclude that the y variable is predicted (or explained) with the respective lag (Mc Quarrie Allan and Chih-Ling, 1998 and Boslaugh and Watters, 2008).

Therefore, based on time-series data and only for statistically significant correlation coefficient calculations, a regression forecast is performed in order to explore whether the correlation will change in the future. To achieve this, since demographic data is available for different age groups, distributed lag regression forecast is applied in order to examine the time-lagged correlations between the number of broadband lines and demographic characteristics. Any change (if existent) is discovered by comparing the values of the correlation coefficient (R) and the b parameter calculated by regression forecast before and after lag movement.

Applying socio-demographic data provided by the General Secretariat of the National Statistical Service of Greece and data regarding the number of broadband lines from July 2006 to June 2009 provided by HTO and the National Regulator Authority, they examine correlations that occur between broadband demand and the following factors:

(1) **Education Level and Age**. It yields that the level of education plays an important role to the people's decision to buy a broadband access line as it explains covariations based on regression analysis results.

Values of beta standardized coefficient b (R = 0999, R2 = 0997) such as PhD, Masters Degree, University Diploma, Technical Education, High School, Junior High School, Elementary School, Abandoned elementary education with reading and writing ability and finally No elementary education without reading and writing ability.

According to results, groups of people with low level education (Junior high school graduates and lower) have bigger influence on broadband demand as high educated persons already or will definitely be users of new services anyhow, no matter their age. They use a correlation matrix with the following variables:

- Total number of Broadband (BB) Lines
- PhD/age
- Masters Degree/age
- University Diploma/age
- Technical Education/age
- High School/age
- Junior High School/age
- Elementary School/age
- Abandoned elementary education with reading and writing ability/age
- No elementary education without reading and writing ability/age

(2) **Income**. The population's income in Greece is increasing even at a slow rate, having a positive effect on broadband demand judging by the extremely high value of the correlation coefficient.

The population's income in Greece is increasing even at a slow rate, having a positive effect on broadband demand; they use a correlation matrix for variables total number of broadband lines and population income. As expected, higher income means more money available for needs and likes other than the fundamental ones with high speed broadband lines being one of the most important contemporary modes of amusement as it is required for a variety of entertainment services.

(3) **Sex and Age**. With regard to the age of men and women

With regard to the age of men and women, they use a correlation matrix for variables total number of broadband lines and Male per age, Female per age.

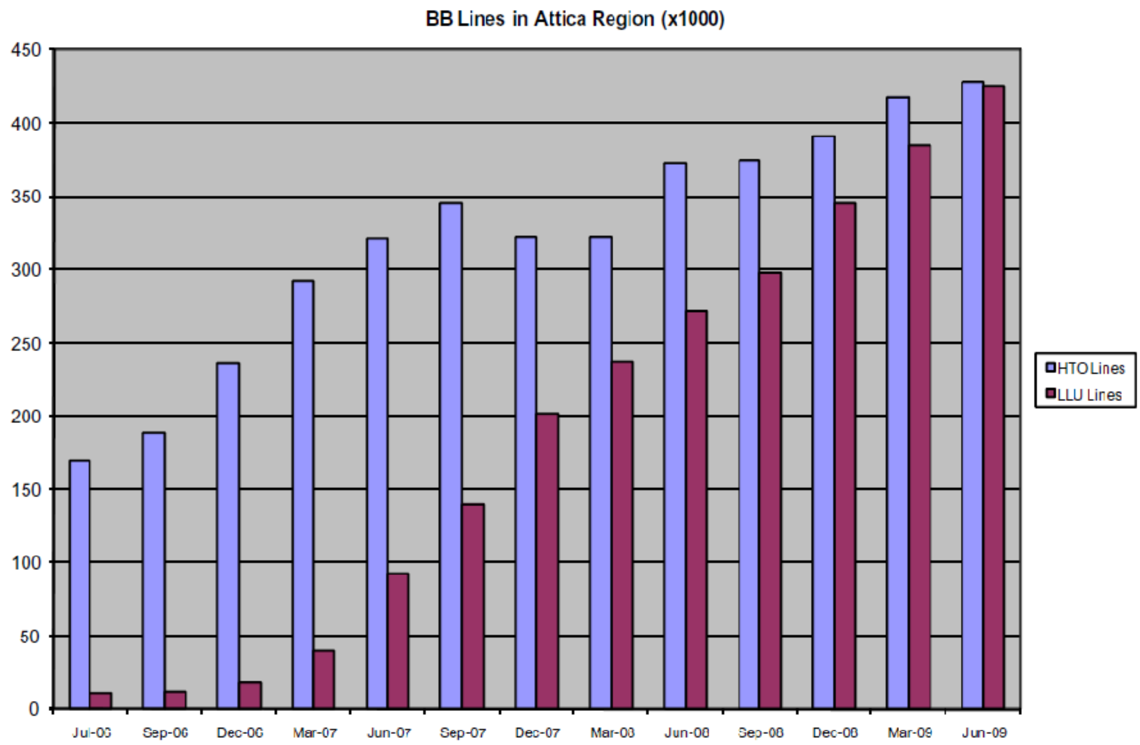
(4)**Marital status and Age**. Regarding the marital status of different age groups.

Regarding the marital status of different age groups, they find that persons living alone, without further obligations have a strong influence on broadband demand. They use a correlation matrix with the below variables.

- Total number of Broadband (BB) Lines
- Single/age, Married/age
- Widow(er)/age
- Divorced/age
- Separated/age.

Especially for the case of Attica they find that:

Due to the high population and respective density of the territory of Attica, it was the first region in which alternative operators meddled and hence constitutes the ideal case to be examined in order to explore the impact of competition on the broadband market in terms of differentiation of the demand for broadband lines provided by the incumbent (HTO) and the alternative operators (LLU Lines). As highlighted by the next diagram, the increase in LLU lines in this region during the last two years is rather impressive, changing the telecommunication landscape and incurring imbalance in the companies' market shares.



Exploring the correlation between demographic characteristics and broadband lines provided by the traditional HTO in comparison with other carriers, they find that broadband lines provided by competitors are strongly related with sex and age, respectively by the correlation matrix for variables HTO Broadband lines, Sex/Age in Attica region and the correlation matrix for variables LLU Broadband lines, Sex/Age in Attica region.

Based on **Yannelis, Christopoulos and Kalantzis [34.]** paper "Estimating the demand for ADSL and ISDN services in Greece" where ***there has been an investigation for the demand for broadband services in Greece, and try to estimate the price elasticity of the demand for ADSL and ISDN services as well the cross-price elasticity between ADSL and ISDN services***.

In this postgraduate thesis we try to investigate the demand for ADSL services in Greece theoretically analyzing the demand for broadband services in the Hellenic market with the use of econometrical methods from related studies.

It is important to mention though, that the slow rate of growth of broadband usage can be either ''supply constrained'', which refers mainly to the less-developed countries that are lagging behind in infrastructure development, or ''demand constrained'' in the case of the developed countries where the majority of the population may have access to fast Internet services.

In Greece there is a ''demand constraint'' as the PC penetration rate is much below the EU average and modems as well as other Internet-related equipment are quite expensive (**Demoussis & Giannakopoulos, 2005**).

Demoussis and Giannakopoulos [32.] in 2005 ***found that the probability of ownership of home computer is influenced by observed household characteristics (e.g., age, education, family composition, income and familiarity with technologically advanced durables), while genuine state dependence and unobserved heterogeneity constitute major sources of observed serial persistence.***

The decision to buy a home computer is assumed to follow a dichotomous choice specification, for household i in year t, which is described by an unobserved continuous latent variable y_{it}^*. This variable describes the underlying process that leads a certain household to buy a home computer, which is in essence a problem of utility maximization under specific income realizations. A probit specification is adopted, according to which the home-computer buying decision is modeled as a dummy variable y_{it}, that variable takes the value of 1 if $y_{it}^* \geq 0$, implying that household *i* owns a home computer, and 0 otherwise.

Under the assumption that the unobserved characteristics e_{it}, which affect home computer ownership, are normally distributed, the probit model takes the form:

$$\Pr(y_{it} = 1) = \Phi(x_{it}b),$$

Where,

x_{it} is a set of observed socio-demographic and economic household characteristics, b are parameter coefficients and Φ() is the corresponding cumulative normal distribution function for the so-called 'pooled' probit. This empirical specification provides a useful descriptive model for the discrete choice under investigation, given the exogenous nature of the covariates used for estimation purposes.

Yet, the simple ‘pooled’ probit model does not take into consideration the panel nature of the data. With repeated observations for every household however, the issue of unobserved time-invariant heterogeneity arises. This issue is typically handled by introducing a random (unobserved) effect term c_i in the error structure, i.e., $e_{it} = c_i + u_{it}$. The term c_i is assumed to capture differences among households (i.e., tastes) for computer ownership, caused by unobserved factors. Therefore, the random effects probit model takes the form:

$$\Pr(y_{it} = 1|x_{it}, c_i) = \Phi(x_{it}b + c_i),$$

Where,

c_i is the unobserved time-invariant household effect. They assume exogeneity between c^i and x_{it}, which implies that conventional maximum likelihood estimation (MLE) methods can be used for the consistent estimation of b and σ_c^2. Further, the variance of the ‘idiosyncratic’ error term (u_{it}) is assumed to be unitary and, thus, the model’s variance due to unobserved heterogeneity is given by $\rho = \sigma_c^2/(\sigma_c^2 + 1)$. The presence of unobserved heterogeneity requires rejection of the null hypothesis that $\rho = 0$, (**Wooldridge, 2002**).

Persistence refers to the relationship between the probability of owning a home computer in year t to past realizations of computer ownership, i.e., t -1. The presence of persistence is typically tested by introducing in $\Pr(y_{it} = 1|x_{it}, c_i) = \Phi(x_{it}b + c_i),$ ı state dependent variable, i.e., lagged values of the dependent variable. Assuming that observations start at t = 0, the dynamic unobserved effects model for t = 1,. . .,T becomes:

$$\Pr(y_{it} = 1|x_{it}, c_i) = \Phi(x_{it}b + \gamma y_{it-1} + c_i),$$

Where,

c_i is again assumed to be exogenous to the contemporaneous covariates of the model. The existence of state dependence requires the rejection of the null hypothesis that $\gamma = 0$, while simultaneously controlling for unobserved heterogeneity, c_i.

The preceding approach however encompasses the _initial conditions_ problem, which refers to the treatment of home computer ownership at t = 0, i.e., y_{i0}. Several econometric procedures have been proposed for incorporating the initial conditions in a dynamic response approach, (Heckman, 1981; Erdem and Sun, 2001; Wooldridge, 2005). In general, the joint distribution of y_{i0} is assumed to be conditional on all outcomes. In the present application we adopt Wooldridge’s suggestion (2005) and include y_{i0} as an additional regressor in the last equation. This implies that all outcomes y_{i1},. . .,y_{iT} are conditional on the initial value y_{i0}. Therefore, the random effects probit model, with state dependence and control for the initial value y_{i0}, becomes:

$$\Pr(y_{it} = 1 | x_{it}, c_i) = \Phi(x_{it} b + \gamma y_{it-1} + a y_{i0} + c_i),$$

Where,

c_i is assumed to be exogenous to x_{it}, y_{it-1}, y_{i0}. Estimation of the previous equation can be carried out by MLE methods, while rejection of the null hypothesis $\gamma = 0$ provides evidence in support of the existence of 'genuine' state dependence, given unobserved heterogeneity.

Economists have repeatedly tried to explain economic behavior by estimating demand functions in an effort to test empirically theoretical frameworks. Existing empirical work on demand functions for telecommunications has produced different functional forms in order to avoid specification problems. In most of these studies the aim has been to measure the impact of prices $P_1,\ldots,P_n$ and income M on the demand for telecommunications services (Y_i) by estimating income, own and cross-price elasticities:

$$\boldsymbol{Y_i = Y(P_1,\ldots,P_n, M).}$$

Yannelis, Christopoulos and Kalantzis empirical analysis is based on an ad-hoc specification of the demand equation, with no reference to the utility maximization problem of the representative consumer. More specifically, it begins by assuming that the prices of ISDN and ADSL are the only factors affecting the demand function for ADSL and ISDN services. Thus, a single-equation model for each service is used, expressed in a structural form that allows for time-varying price elasticities.

This form is represented by the following equation:

$$\ln Y_{it} = \delta_i + \beta_{1i} P_{1t} + \beta_{2i} P_{2t} + u_{it} \quad i = 1, 2$$

Where,

Y_{1t} and Y_{2t} denote the number of subscribers for ADSL and ISDN services, respectively, P1t is the price for ADSL, P_{2t} is the price for ISDN and δ is the constant term.

In this framework, the own and cross-price elasticities of the demand for ADSL and ISDN services are determined by the magnitude of the parameters β_{11}, β_{22} and β_{12}, β_{21}, respectively. All variables are in levels, except for the dependent variables, which are in logs. The u_{ti} variables represent the random error that includes all other factors that affect the behavior of the dependent variable. The error term is assumed to satisfy all standard regression assumptions.

This approach needs careful attention to the stochastic properties of the series because potential trends in time series data have important implications for the choice of appropriate estimators. Assuming that the data are characterized by stochastic trends, as it accrues from other studies, then the use of standard statistical techniques of parameters restrictions by OLS are not reliable. Several procedures have developed in order to overcome such problems when estimating demand functions. The most commonly used is the Cointegration method, which tests whether or not two or more series drift apart without bound over time Assuming that the set of ADSL and ISDN subscribers and their prices is cointegrated, the Johansen method is applied through the following steps. Firstly, it is found that the variables are indeed integrated to the same order and therefore, Dickey–Fuller (DF) and augmented Dickey–Fuller (ADF) tests are applied for this purpose. If the evidence suggests that for each series of the data set are integrated to the same order and their residual sare white noise, the second step follows where the cointegrating relationship is implemented and estimated.

Every equation of the system represents a cointegrating relationship and can be written as a Vector Error Correction (VEC) model. A VEC model is a restricted Vector Autoregression (VAR) model designed for use with non-stationary series that are known to be cointegrated. The VEC has cointegration relations built into specification so that it restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The cointegration term is known as the correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

The VEC has the following form:

$$\Delta \ln Y_{it} = \delta_{it} + \gamma_{it} t + \beta_i u_{it-1} + \sum a_{ij} \Delta P_{it-j} + e_{it} \quad i = 1,2$$

In the model investigated in this postgraduate thesis we have that:

$$\textbf{DEMAND}_{\textbf{ADSL}} = \textbf{f(P, Speed, S, GDP, Unemployment)}$$

Where,

- **P:** Price, the monthly subscription charge per speed used for home Internet Service
- **Speed:** Describes the time it takes to send/receive information to and from the home Computer.
- **S:** The number of subscribers for ADSL services categorized by speed
- **GDP:** Gross Domestic Product, the measure for household income and
- **Unemployment:** as defined by the International Labor Organization, occurs when people are without jobs and they have actively looked for work. The unemployment rate is a measure of the prevalence of unemployment and it is calculated as a percentage by dividing the number of unemployed individuals by all individuals currently in the labor force.

All the above parameters can be gathered quarterly from HTO [6.], and from the **Hellenic Statistical Authority (EL.STAT) [35.]**.

We are going to use Panel Data to estimate the demand for ADSL services. A panel is a cross-section or group of people who are surveyed periodically over a given time span. Panel data analysis is a method of studying a particular subject within multiple sites, periodically observed over a defined time frame. With repeated observations of enough cross-sections, panel analysis permits to study the dynamics of change with short time series. The combination of time series with cross-sections can enhance the quality and quantity of data in ways that would be impossible using only one of these two dimensions. Panel analysis can provide a rich and powerful study of a set of people, if one is willing to consider both the space and time dimension of the data.

Panel data analysis endows regression analysis with both a spatial and temporal dimension. The spatial dimension pertains to a set of cross-sectional units of observation.

An approach on how broadband penetration affects economic growth have been done by **Pantelis Koutroumpis [31.]**. ***A macroeconomic production function with a micro-model for broadband investment is used to estimate the impact of broadband infrastructure and growth***. There has been made an attempt to measure the economic impact of the telecommunications infrastructure on growth and more specifically the effects of broadband infrastructure. The growing numbers of internet subscribers worldwide make this study particularly important. This issue has also received considerable regulatory and public policy attention especially in the developed countries. There are used evidence from 22 OECD countries over 6 years to estimate the impact of broadband infrastructure.

Koutroumpis estimate the effect of broadband infrastructure on growth using a simultaneous equations model. This model endogenizes broadband Investment by incorporating broadband supply, demand and output equations. The system is then jointly estimated with a macroproduction function hence accounting for the simultaneity effects.

This work adds to this emerging field by incorporating a simultaneous approach methodology that endogenises supply, demand and output and provides measurable estimates for impact of the broadband network externalities for the OECD countries.

The results suggest that there are increasing returns to broadband telecommunications investments, which are consistent with the persistence of network effects. What has been seen is that there is evidence of a critical mass phenomenon in broadband infrastructure investments.

As mentioned the approach used here is a structural econometric model within a production function framework that endogenizes telecommunications investment. The reason for using this type of model is the following. The effect he is trying to capture is a two-way relationship between growth and broadband infra- structure. While we do expect wealthier people to have higher demand for goods and services he wants to estimate how much the country's growth might be affected by their use of the broadband networks. In order to illustrate this causal link between the two variables he uses this model that explicitly disentangles the values in a simultaneous equations model. Therefore a micro-model of supply and demand is specified and jointly estimated with the macroproduction equation. This way while endogenizing for the investment we can control for the causal effects of this two-way relationship

The national aggregate economic output (GDP) is used in the production function and is related to labor and capital in each country. In particular the stock of capital net of telecommunications capital (K), the stock of human capital (HK) and the stock of broadband infrastructure (BROADBAND). The stock of broadband infrastructure is needed rather than the broadband investment because consumers demand infrastructure and not investment.

The model used here is based on the Roeller andWaverman (2001) simultaneous equations model. The aggregate production function is as follows:

$$\text{GDP}_{it} = f(K_{it},\ \text{HK}_{it},\ \text{BROADBAND}_{it})$$

GDP_{it}: GDP in millions USD ($)
K_{it} : Non- residential stock of telecommunications investment in millions USD ($)
$BROADBAND_{it}$: Broadband price ($, constant)
The subscripts i and t correspond to country and time values, respectively.

There is a wide literature about the strong relationship between stock of capital and labor force in a country with the GDP.
The variable for capital used here is split between telecommunications capital $BROADBAND_{it}$ and all other capital K_{it}. The telecommunications capital for the 22 OECD countries is measured by their broadband infrastructure and not by their fixed telephony infrastructure. The reason for that is that the country sample has higher than 100% penetration in fixed telephony thus indicating homogeneity in this kind of infrastructure. Building broadband infrastructure requires both access and back bone net work investments on top of the legacy infrastructure. Broadband penetration in each country is used as a proxy for the level of upgrade of the older networks.
In order to differentiate between the effect of BROADBAND on GDP and the inverse we specify the following micro- model.

<u>Demand for broadband infrastructure</u>

$$\text{BROADBAND}_{it} = h(\text{GDPC}_{it}, \text{BBP}r_{it}, \text{EDU}_{it},\ \text{URB}_{it},\ \text{RND}_{it})$$

GDPCit: GDPC in USD ($)
$BBPr_{it}$: Price of 1Mbyte per second of flat rate internet connection (no data or time caps)
EDU_{it}: Percentage of GDP spent for education (%)
URB_{it}: Percent of population living in areas with densities higher than 500 inhabitants per square kilometer
RND_{it}: Percent of GDP spent on public or private research and development
The subscripts i and t correspond to country and time values, respectively.

The demand equation states that broadband penetration is a function of GDP per capita, the price of a standard service for the connection to the network, the percent of GDP spent on education, the percentage of the population that lives in densely populated areas and the percent of GDP spent on public or private research and development.

Supply of broadband infrastructure

$$BBI_{it} = g(BBPr_{it}, InterPlatform_{it}, \ Regulation_{it})$$

BBI_{it}: Stock of telecommunications investment in millions USD ($)
$BBPr_{it}$: Price of 1Mbyte per second of flat rate internet connection (no data or time caps)
$InterPlatform_{it}$: InterPlatform index equal to the sum of squares of broadband connections per platform (Cable, DSL, FTTH) divided by the square of the total number of broadband connections
$Regulaton_{it}$: Percent of DSL lines over local loop unbundling relatively to total broadband
The subscripts i and t correspond to country and time values, respectively.

The supply equation links the aggregate broadband investment in a country to broadband price levels for that period, the level of inter-platform competition in the broadband market and the mandate of local loop unbundling on the incumbent's network as a measure of regulatory control. All these parameters affect potential and existing operators as well as the dynamic of the supply side of the market.

Finally the Inter-platform variable was constructed from ITU data as well as the regulation variable. These variables are computed with the following equations:

$$InterPlatform_{ij} = \sum_{1}^{n} \left(\frac{Platform_m}{Total\ BB} \right)^2$$

$$Regulation_{it} = \frac{Full\ LLU + Shared\ LLU}{(Total\ BB\ Connections)}$$

The platforms taken into account are DSL, Cable, Fiber and othe rbroadband. There fore the range of this metric is $0.25 < InterPlatform_{ij} < 1$.

Broadband infrastructure production function

$$BROADBAND_{i,t} - BROADBAND_{i,t-1} = k(BBI_{it})$$

The infrastructure equation states that the annual change in broadband penetration is a function of the capital invested in a country during 1 year.

Variables used in the model and descriptions.

GDP_{it}	GDP in millions USD ($)
$GDPC_{it}$	GDPC in USD ($)
K_{it}	Non-residential stock of telecommunications investment in millions USD ($)
PEN_{it}	Level of broadband penetration in 100 inhabitants
$BBPr_{it}$	Price of 1 Mbyte per second of flat rate internet connection (no data or time caps)
URB_{it}	Percent of population living in areas with densities higher than 500 inhabitants per square kilometer
EDU_{it}	Percentage of GDP spent for education (%)
RD_{it}	Level of public and private investment in research and development as percentage of GDP(%)
BBI_{it}	Stock of telecommunications investment in millions USD ($)
LF_{it}	Population with full or part time work aged 15–64 in thousands
$Interplat_{it}$	Herfindahl index equal to the sum of squares of broadband connections per platform (Cable, DSL, FTTH) divided by the square of the total number of broadband connections
Reg_{it}	Percent of DSL lines over local loop unbundling relatively to total broadband

and,

Variable
GDP ($ millions, constant 2000)
GDPC ($, constant 2000)
Labor (thousands population)
Non ICT stock of capital ($ millions, constant 2000)
Broadband penetration (%)
Education (%)
Broadband price ($, constant 2000)
Research and development (%)
Urbanization (%)
Broadband investment ($ millions, constant 2000)
Inter-platform index (HHI)
Regulation (%)

The dataset used for this study uses annual data from 22 OECD countries for the 6-year-period between 2002 and 2007. The countries used, are listed below.
OECD countries used in the dataset:

Australia	**Luxembourg**
Austria	**Japan**
Belgium	**Netherlands**
Canada	**New Zealand**
Denmark	**Norway**
France	**Portugal**
Germany	**Spain**
Greece	**Sweden**
Hungary	**Switcherland**
Ireland	**United Kingdom**
Italy	**United States**

While the time period for the sample of this study is only 6 years it does manage to capture a very important part of the growth of broadband networks in the OECD sample.
The data used have been collected by various sources depending on their nature and availability. World Bank online resources were used to obtain information related to GDP, GDPC, labor force – population with full or part time work aged 15–64, education and research and development funding as percentage of GDP.
The Groeningen Growth Accounting Database was used to obtain information about the nonresidential capital stock net of telecommunications investment and the total telecommunications investment. A combination of data from OECD statistics and International Telecommunications Unions statistics was used to construct the variable of the broadband price which utilized a level of constant speed at flat rate contract to obtain an unbiased benchmark of the price levels.

GDP (Labor force, Non ICT stock of capital, BB penetration)
Penetration (GDPC, BB price, Education, R&D, Urbanization)
BB investment (BB price, Inter-platform, Regulation)

Rosston, Savage and Waldman 2010 [26.] give a survey to help ***determine consumer valuations of different aspects of broadband Internet service.***

The random utility model is used to estimate marginal utilities and calculate Willingness to pay. Their empirical results show that reliability and speed are important characteristics of Internet service. A linear approximation to the household conditional utility function is:

$$\mathbf{U^* = \beta_1 COST + \beta_2 SPEED + \beta_3 RELIABILTY + \beta_4 MOBILE\ LAPTOP + \beta_5 MOVIE\ RENTAL + \beta_6 PRIORITY + \beta_7 TELEHEALTH + \beta_8 VIDEOPHONE + \varepsilon}$$

Where:

- price per month for Internet service (COST)
- reliability of the connection to the Internet (RELIABILITY)
- time it takes to download and upload information (SPEED)
- connect a laptop to the Internet wirelessly while away from home (MOBILE LAPTOP)
- download high-definition movies and TV shows (MOVIE RENTAL)
- designate some downloads as high-priority so they travel through the Internet at relatively faster speed (PRIORITY)
- interact with health specialists online (TELEHEALTH)
- place free phone calls over the Internet and see the person being called (VIDEOPHONE)
- U^* is utility, β_1 is the marginal disutility of COST, β_2 and β_3 are the marginal utilities for the Internet service features SPEED and RELIABILITY, β_4 through β_8 are the marginal utilities for the Internet service activities MOBILE LAPTOP, MOVIE RENTAL, PRIORITY, TELEHEALTH and VIDEOPHONE, and ε is a random disturbance.

The marginal utilities have the usual partial derivative interpretation - the change in utility from a one-unit increase in the level of the feature or activity. *SPEED* and *RELIABILITY* are standard features of all current Internet services; they cannot be unbundled. Given that "more is better", *a priori* expectation for these two features is $\beta_2, \beta_3 > 0$. For example, an estimate of $\beta_2 = 0.2$ indicates that a one unit improvement in *SPEED*, measured by a discrete improvement from "Slow = 1" to "Fast = 2", increases utility by 0.2 for the representative household. *COST* is also a standard service feature, however, a higher cost of service provides less satisfaction so $\beta_1 < 0$. In contrast to the features *COST*, *SPEED* and *RELIABILITY*, the activities *MOBILE LAPTOP*, *MOVIE RENTAL*, *PRIORITY*, *TELEHEALTH* and *VIDEOPHONE* are not widely available in Internet services and/or can be unbundled.

The signs and magnitudes of the marginal utilities for these hypothetical features, $\beta 4$ through $\beta 8$, within a bundled Internet service are an empirical question. Since the estimates of marginal utility (such as an increase in utility of 0.2 as described above) do not have a readily understandable metric, it is convenient to convert these changes into dollar terms. This is done by employing the economic construct of willingness-to-pay.

For example, the WTP for a one unit increase in *SPEED* (*i.e.*, the discrete improvement from "Slow" to "Fast") is defined as how much more the Internet service would have to be priced to make the consumer just indifferent between the old (cheaper but slower) service and the new (more expensive but faster) service:

$$\beta_1 COST + \beta_2 SPEED + \beta_3 RELIABILITY + \beta_4 MOBILE\ LAPTOP$$
$$+ \beta_5 MOVIE\ RENTAL + \beta_6 PRIORITY + \beta_7 TELEHEALTH + \beta_8 VIDEOHONE$$
$$=$$
$$\beta_1 (COST + WTP) + \beta_2 (SPEED + 1) + \beta_3 RELIABILITY + \beta_4 MOBILE\ LAPTOP$$
$$+ \beta_5 MOVIE\ RENTAL + \beta_6 PRIORITY + \beta_7 TELEHEALTH + \beta_8 VIDEOHONE$$

Solving algebraically for WTP in equation 2 gives the required change in cost to offset an increase of β_2 in utility: $WTP(Speed) = -\beta_2/\beta_1$.

Households may not have identical preferences. Preferences towards speed, for example, may differ because of observable demographic characteristics, or may be idiosyncratic. It is possible to estimate differences in the marginal utility of specific service features to different households by interacting those features with demographic variables. For instance, suppose households in urban and rural locations value speed differently. A specification of utility that captures this difference is:

$$U^* = \beta_1 COST + (\beta_2 + \eta RURAL)\times\beta_2 SPEED + \beta_3 RELIABILITY + \beta_4 MOBILE\ LAPTOP$$
$$+ \beta_5 MOVIE\ RENTAL + \beta_6 PRIORITY + \beta_7 TELEHEALTH + \beta_8 VIDEOHONE + \varepsilon$$

Where,

η is an additional parameter to be estimated, and *RURAL* is a dummy variable that is equal to one when the respondent is in a rural location, and zero otherwise. When location is not important ($\eta = 0$), the WTP for a one-unit improvement in connection speed is $-\beta_2/\beta_1$. When location is important ($\eta \neq 0$), the WTP for a one-unit improvement in connection speed in a rural location is:

$$WTP\ (Speed) = -(\beta_2 + \eta)/\ \beta_1.$$

The last equation provides a concrete illustration of how WTP estimates will inform the design of government programs to promote broadband Internet service in under-served areas.

For example, policy makers can use this equation to compare rural valuations for broadband to the cost of service provision, and then make a more accurate judgment of the potential subsidy required or, not required, for individual broadband adoption and/or infrastructure deployment in rural areas.

Internet Service Characteristics

Characteristic	**Levels**
COST	The amount the household pays per month for home Internet service
SPEED	Slow: Similar to dial up. Downloads from the Internet and uploads to the Internet are slow. It is good for emailing and light web surfing. Fast: Much faster downloads and uploads. It is great for music, photo sharing and watching some videos. Very fast: Blazing fast downloads and uploads. It is really great for gaming, watching high-definition movies, and instantly transferring large files.
RELIABILITY	Very reliable Internet service is rarely disrupted by service outages, that is, your service may go down once or twice a year due to severe weather. With less reliable Internet service you will experience more outages, perhaps once or twice a month for no particular reason.
MOBILE LAPTOP	Yes, I can use my Internet service to connect my laptop to the Internet wirelessly while away from my home. No, I cannot use my Internet service to connect my laptop to the Internet wirelessly while away from my home.
MOVIE RENTAL	Yes, I can use my Internet service to download and watch highdefinition movies and TV shows. No, I cannot use my Internet service to download high-definition movies and TV shows.
PRIORITY	Yes, I can use my Internet service to designate some of my downloads as high priority. No, I cannot use my Internet service to designate some of my downloads as high priority.
TELEHEALTH	Yes, I can interact with my health care specialists through my Internet service. No, I cannot interact with my health care specialists through my Internet service.
VIDEOPHONE	Yes, I can place free calls through my Internet service and see the person I am calling. No, I cannot place calls through my Internet service.

They also use:

- Demographic Distributions
- Probit Estimates of Inexperienced users
- Statistics for Internet Service features and Hours Online
- Frequency of Internet Activity
- Baseline Estimates of utility:
  - by existing Internet Connection Speed
  - by downloading digital video
  - by smart phone ownership
  - web cam ownership
  - by Age
  - by Education
  - by Income
  - by Race
  - by Location
  - by speed of Internet connection

All above data are gathered from Survey Questions.

Savage, Waldman 2005 [24.] investigate *household awareness of high-speed Internet access profile Internet access and use, and gain insight into how important always-on, price, speed, installation, and reliability attributes are in their choice of service.*

Willingness to pay estimates indicates reliability of service, speed and always on connectivity are important Internet access attributes. Willingness-to-pay estimates indicate reliability of service, speed, and always-on connectivity, are important Internet access attributes.

They investigate two common ways to obtain broadband Internet access are with a cable modem provided by a cable company, or a digital subscriber line (DSL) provided by a telephone company and signing up for a service plan at an additional price over traditional cable TV and telephone services from these providers. DSL uses copper telephone wires with a computer digital network to provide high-speed Internet access without the need for a fiber optic transport line from the residence or place of business. Cable uses the traditional coaxial cable for transport to and from the residence.

In some geographical areas, broadband is also available through fixed wireless and satellite providers. With wireless, line-of-sight transmission towers connected to the Internet send and receive information to and from the personal computer (PC) and the Internet backbone. Satellite Internet is similar to satellite TV. Users send and receive information to the backbone via their dish and a receiver in space.

The price of residential Internet service includes the access price and switching costs incurred when choosing a new access plan over an existing one. The price of Internet access has two components.

The first component is the price of transport from the home PC to the Internet backbone which is typically paid to traditional telephone and cable companies.

The second price component is the monthly subscription charge to Internet service providers (ISPs) who provide ‘‘user-friendly’’ portals to the wide array of activities, information, and services available on the World Wide Web.

Switching costs derive from contractual commitments, installation costs (including the implicit costs from concern about technical difficulty of installation), training costs (including implicit costs from concern about the technical difficulty of learning and maintaining the service), search costs, and psychological costs (for instance, consumers may not trust their local-exchange carrier (LEC) or may be uncertain about the financial viability of new DSL market entrants). Changing from one ISP to another also requires subscribers to change their e-mail address. Here, switching costs include a charge for having future e-mails re-directed, the costs of informing all correspondents of your new address and potentially the cost of lost business. Switching costs may be mitigated to some extent for dial-up users by the reduction in ISP prices and the removal of the unneeded second line.

Speed describes the time it takes to send and receive information to and from the home computer and/or device. Different providers of service can supply different amounts of bandwidth and speed.

Broadband connection, provided by DSL, cable modem, fixed wireless and satellite, offers transmission rates up to 20–50 times faster than a traditional dial-up connection and better access to bandwidth-intensive content. Broadband definitions vary widely but generally refer to ‘‘significantly faster data rates than narrowband’’ with always-on and two-way functionality.

Since broadband Internet access is always on and allows simultaneous transmission of Internet and voice traffic, the always-on attribute has also become synonymous with the convenience of using the Internet and making telephone calls at the same time. Integrated delivery of data, video, and voice services eliminates busy signals and dropped connections during Internet sessions and the need for an extra telephone line dedicated to Internet access.

Some Internet access plans are very reliable. Users can count on the service being available whenever they want to use it and any problems that do arise are immediately handled by good customer service.

Ease of installation reflects the time, cost, and complexity of ordering and installing a broadband connection. While DSL installation has historically been associated with configuration problems, trouble-shooting, and repeated visits by technicians, both cable and DSL providers appear to have streamlined this process in more recent times.

Many cable and DSL providers will provide free installation but this does not free the residential consumer from the inconvenience costs of on-site visits. A trend toward self-installation kits and ‘‘plug-and-play’’ modems reduces company and consumer monetary and time costs by reducing the number of call-outs.

Respondents are assumed to behave in a manner consistent with the maximization of utility (U):

$$\mathbf{U^* = \beta_1 ALWAYS\text{-}ON + \beta_2 SPEED + \beta_3 PRICE + \beta_4 INSTALLATION + \beta_5 RELIABLE + \varepsilon}$$

Where:

Always on: no dial-up is required for Internet connection and respondents can Simultaneously place telephone calls

Price: is the fixed monthly cost for unlimited usage

Speed: describes the time it takes to receive and send information to and from the home computer Speed is either very fast for uploads and downloads (very fast), or fast for downloads but relatively slower for uploads (fast), or the same as dial-up (slow).

Installation: of Internet access service can be immediate, within one week and within several Weeks

Reliable: Very reliable Internet access is never disrupted (i.e., there are no service outages), however, with less reliable Internet access, users may occasionally experience outages that require customer support.

And the β’s are parameters to be estimated and e is a random disturbance. Note that attributes have been coded for estimation so that the expected signs for β_1 through β_5 are negative. For instance, utility is expected to be less when price increases so $\beta_3<0$. The hypothetical utility of each service option, U*, is not revealed. Instead, what is known is which option has the highest utility.

Individuals may not have identical preferences. An individual’s preference for speed, for example, may differ because of observable demographic characteristics. This can be examined by estimating the previous equation on sub-samples of the data which have the effect of allowing all parameters to be different for individuals in different socioeconomic groups. It is also possible to observe differences in the marginal utility of specific service attributes by interacting those with demographics.

A model that captures this difference is:

$$\mathbf{U^* = \beta_1 ALWAYS\text{-}ON + (\beta_2 + nEDUC)SPEED + \beta_3 PRICE + \beta_4 INSTALLATION + \beta_5 RELIABLE + \varepsilon}$$

Where,

n is an additional parameter to be estimated and EDUC is education. Here, the WTP for a one unit improvement in speed is $+ (\beta_2 + nEDUC)/ \beta_3$.

Also, in **Glass, Stefanova [27.]** there are investigated the ***factors that will encourage broadband adoption in rural areas***.

They find that low density, high cost markets decrease the ability of the telecommunication service providers to offer DSL, but other factors also play a role. Demand for broadband has become more inelastic over time, marginal increases in speed alone have lost their appeal to customers, and the inclusion of video in a broadband package improves broadband take rates and willingness to pay. Small income elasticities reinforce their finding that broadband has become a necessity. Their analysis shows that price subsidies may not be effective in providing a large boost in demand, but policies that lower the cost of providing video may stimulate broadband adoption indirectly if the savings lead to more affordable bundled communications multimedia packages that users want.

Glass and Stefanova model the rural companies' decision to offer broadband service and the customers' decision to buy the service.

Summary statistics for variables used in estimation

Variables:

- ***2005***
  - **DSL provision (binary)**
  - **Mean distance (miles)**
  - **Number of exchanges**
  - **Percent without telephone**
  - **Presence of competitor (binary)**
  - **Lines per exchange**
  - **DSL lines**
  - **Price (in $)**
  - **Speed (Kbps)**
  - **Income per household (in $)**
  - **Local residential rates (in $)**
  - **Households within 18,000 feet of wire center**
  - **Video (binary)**

- ***2009***
  - **DSL provision (binary)**
  - **Mean distance (miles)**
  - **Number of exchanges**
  - **Percent without telephone**
  - **Presence of competitor (binary)**
  - **Lines per exchange**

- **DSL lines**
- **Price (in $)**
- **Speed (Kbps)**
- **Income per household (in $)**
- **Local residential rates (in $)**
- **Households within 18,000 feet of wire center**
- **Video (binary)**

Offer equation

A profit maximizing company will offer DSL services if the present value of the future revenue flow is greater than the present value of future cost flow, that is, the DSL service has a positive net present value. The natural framework to model such decisions is that of a probit. The net present value of DSL service (Y^*) is a latent variable, which we do not observe, but its value determines a binary offer variable (Y) which takes the value of 0 if $Y^* < 0$ and value of 1 if $Y^* > 0$. Y^* is a function of market size, presence of competitors and cost shifters which we observe. Empirical model is given by:

$$Y_i^* = \alpha_1 + \alpha_2 Dist_i + \alpha_3 No\_Ex_i + \alpha_4 Lines\_Per\_Ex_i + \alpha_5 Notel\_Pct_i + u_i$$

and

$$Y_i = 1 \text{ an } Y_i^* > 0,$$
$$Y_i = 0 \text{ an } Y_i^* < 0$$

Where:

Dist: is the mean distance of customers from a wire center of company *i*,
No_Ex: is the number of exchanges in a rural telephone company *i*,
Lines_Per_Ex: is the number of lines per exchange,
Notel_Pct: is the percent of people without a telephone and
u*:* is a random error term.

They assume a normal distribution for *u* and analyze the company's decision to offer DSL services using a probit model. The number of exchanges, lines per exchange, and telephone penetration rate serve as proxies for market size. They expect positive effects of these variables on the decision to provide DSL. They also expect a negative impact of mean distance from customers to the wire center on the provision of DSL as this variable is intended to capture cost of deployment.

<u>Take rate equation</u>

For the companies offering DSL they model the number of lines the customers buy.
Demand for DSL will depend on price for the service, price of traditional voice service, customer preferences toward the broadband service as opposed to dial-up, and household income levels. Network restrictions may also affect the take rates of DSL with some lines not even eligible for the service. Separating the degree to which relative availability in rural areas, versus pricing, speed, quality, and other determinants shape end user demand, is the reason why we include the number of households within 18,000 feet of a wire center in our demand equation.

$$\mathbf{DSL_i = \beta_0 + \beta_1 Price_i + \beta_2 Speed_i + \beta_3 HHincome_i + }$$
$$\mathbf{+ \beta_4 LocalRate_i + \beta_5 Video_i + \beta_6 HH\_18kft_i} + \boldsymbol{v_i}$$

Where:

$\boldsymbol{DSL_i}$: denotes number of DSL lines in a study area i,
$\boldsymbol{Price_i}$*:* is the DSL retail price,
$\boldsymbol{Speed_i}$*:* is the DSL advertised download speed,
$\boldsymbol{HHincome_i}$*:* is the measure for household income,
$\boldsymbol{LocalRate_i}$*:* is the residential rate for telephone service,
$\boldsymbol{Video_i}$: is a dummy variable for the availability of video services,
$\boldsymbol{HH\_18k\ ft_i}$:represents the number of households within 18,000 feet and
$\boldsymbol{v_i}$: is a well-behaved error term.

The demand equation will reflect the demand in only those study areas that have DSL access available, which may not be a random sample of companies. If the decision to offer DSL is correlated with the decision of how many lines to offer, an OLS estimate of the take rate equation will be biased and cannot be extrapolated to the population at large (i.e. sample selection bias). The distribution of the error terms of the offer and the take rate equations is assumed to be bivariate normal with correlation ρ. The two equations are related if ρ not equals zero.

Another important issue with the estimation of the model and the interpretation of the results is the potential endogeneity of the price variable. Prices of DSL are determined by the interaction between supply and demand and are inherently endogenous in the take rate equation, thus, leading to simultaneous equation bias and inconsistent estimates of the price elasticity. If the price variable is endogenous, our results may be understating the significance and magnitude of the price effect on take rates.
Larger number of exchanges and lines per exchange increase the likelihood that DSL service will yield a positive return to the company over its life span. Percent of customers without

telephone service, number of exchanges per study area and lines per exchange achieve statistical significance in the 2005 model. Mean distance to the customers and presence of competitors in the study area are insignificantly different from zero.

The coefficients ρ and λ in the 2005 sample selection model demonstrate a statistically insignificant correlation between the decision to provide DSL and the number of lines provided. Lack of market potential and long distances to the intercity backbone network were the reasons for many rural companies not to offer high-speed Internet services in 2005 (see Glass 2006). Furthermore, for some companies this decision may have been driven by the lack of trained professionals and knowledge of the relatively new technology. The combination of market size and technological factors may be sending mixed signals leading to the insignificance of the correlation between the offer and take rate decisions in 2005. Four years later, in 2009, advancements in technology have made it cheaper to provide the broadband service to more dispersed geographical areas and more companies have become comfortable with the technology and started offering the service. As a result only a smaller percent of rural companies did not offer DSL in 2009 than in 2005. Companies that still do not provide DSL in 2009 do so primarily because the small market potential in the sparsely populated rural areas makes it economically unattractive.

Results of the estimations

Take rate equation	2005 Model Coefficients	2005 Model Elasticities	2009 Model Coefficients	2009 Model Elasticities
Intercept	−808.914 (−1.59)	–	−1009.733 (−1.76)	–
DSL price	−13.74 (−1.9)	−0.66[a]	−7.277 (−2.28)	−0.212[b]
DSL speed	0.395 (1.88)	0.25[a]	−0.047 (−0.96)	−0.044
Household income (in $1,000)	21.353 (1.39)	0.63	15.13 (1.90)	0.605[a]
Local residential rate	58.11 (1.39)	1.15	−7.11 (−0.540)	−0.067
Households within 18,000 feet (in 100 per square mile)	19.793 (3.58)	0.80[b]	75.927 (15.04)	1.088[b]
Video	1254.054 (3.07)	1.63[b]	722.385 (5.32)	0.426[b]
Selection equation	**2005 Model Coefficients**	**2005 Model Marginal effects**	**2009 Model Coefficients**	**2009 Model Elasticities**
Intercept	0.854(5.66)	–		
Mean distance (miles)	−0.022(−1.42)	−0.022		
Percent without telephone	−0.052(−5.45)	−0.053[b]		
Number of exchanges	0.041(8.55)	0.041[b]		
Lines per exchange (in 100 per exchange)	0.231(4.75)	0.231[b]		
Competitor present	−0.003(−0.04)	−0.003		
ρ	−0.347(−1.64)			
λ	−507.298(−1.54)			
Number of observations	672		362	
Censored observations	96			
Log likelihood	−5324.86			
Adj R^2			0.79	

Notes: 1. T-statistics in parenthesis; 2. The exception to the elasticity calculation is the video variable as it is a binary variable. Elasticities are calculated as the average elasticities in the sample; 3. Standard errors are adjusted for heteroskedasticity

[a]Indicates significance of the corresponding coefficient above the 5% confidence level

[b]Indicates significance of the corresponding coefficient above the 10% confidence level

Price and *Income* have the expected signs. Higher DSL prices depress and higher incomes stimulate demand for DSL. The result for *Speed* has the expected positive sign and is marginally significant in the 2005 model, but it is negative and statistically insignificant in 2009. Marginal increases in *Speed* no longer provide boost in demand for DSL.

The local residential rate is large and positive in 2005 and small and negative in 2009. It is insignificant in both time periods. The positive relationship between the local residential rate and take rates in 2005 indicates that users considered dial-up and broadband as substitutes and relative prices had an effect on the decision of dial-up users to subscribe to broadband. In 2009, the relationship is small and very insignificant.

Companies offering video services have higher demand for DSL in both years. Customers are attracted to the ability to use multimedia Internet applications. This effect is consistently significant across both years and model specifications. Lack of technical limitations or large market size, measured by the number of households within 18,000 feet of a wire center, significantly increases DSL take rates.

The low price elasticity found in the 2009 study indicates that broadband access has become more of a necessity than it used to be in 2005. The low price sensitivities of households who already subscribe to broadband in our study are in contrast with results from household surveys of users and non-users.

As for income elasticity, the estimates are positive but below unity, indicating that broadband services constitute a normal good in economic sense.

Panel data is a stack of cross sectional data for the same companies observed over different time periods. Since panel data allows us to follow individual firm's history over time, it is a natural extension of cross section data and it allows us to add another dimension to our analysis. The methodology used for panel data helps solve two important problems of cross section data analysis—unobserved heterogeneity and omitted variable bias unless the omitted variable is time varying. As the factors in the selection equation do not vary over time, we no longer need the selection equation in the panel model.

$$\mathbf{DSL_{it} = \mu_t + \beta_1 Price_{it} + \beta_2 Speed_{it} + \beta_3 HHincome_{it} + \beta_4 LocalRate_i + \beta_5 Video_{it} + \beta_6\, HH\_18kft_i + \alpha_i + v_{i,}} \quad \text{για } t = 1,2.$$

$LocalRate_i$ and HH_18kft_i are observable individual specific time invariant independent variables, $Price_{it}$, $Speed_{it}$, $HHincomei_t$, and $Video_{it}$ are variables that vary over time, α_i is an individual specific time invariant error term, μ_t is a constant for each time period and v_{it} is an IID error term.

Taking the two period difference of the equation, we get:

$$DSL_{i2} - DSL_{i1} = (\mu_2 - \mu_1) + \beta_1(Price_{i2} - Price_{i1}) + \beta_2(Speed_{i2} - Speed_{i1}) + \beta_3(HHincome_{i2} - HHincome_{i1}) + \beta_4(LocalRate_{i2} - LocalRate_{i1}) + \beta_5(Video_{i2} - Video_{i1}) + (\nu_{i2} - \nu_{i1}) \quad (5)$$

Or

$$\Delta DSL_i = \mu + \beta_1 \Delta Price_i + \beta_2 \Delta Speed_i + \beta_3 \Delta HHincome_i + \beta_4 \Delta LocalRate_i + \beta_5 \Delta Video_i + \Delta \nu_i \quad (6)$$

The time invariant effects fall out of the equation and are no longer relevant in estimation. Assuming that P*rice*, S*peed*, *Income*, *Local Rate* and *Video* are the only time variant determinants of DSL demand, we estimate a fixed effects model by taking the difference scores of the variables.

Finally, in **Yuji Akematsu [25.]** article there has been ***an investigation to the migration from ADSL to FFTH (Fiber To The Home). This paper focuses on the ADSL market and heuristically analyzes the factors promoting it by using data of its subscribers. The purpose of their paper is to estimate the effect of deregulation as such on ADSL carriers, and specify the factors promoting Japanese ADSL which is the major technology of Japanese broadband.***
A model for panel data estimation is formulated as follows:

$$\ln S_{it} = \beta_0 + \beta_1 \ln P_{it} + \beta_2 \ln G_t + \sum_j \beta_3^j D_{it}^j + u_{it}$$

$$u_{it} = \lambda_i + v_{it}$$

Where,
S_{it} denotes the number of subscribers,
P_{it} the monthly subscription charge (per 1Mbps),
G_t real GDP converted into monthly data by moving average method of 3 quarters, and
D_{it} dummy variables attached to factors which take 0 before the events started and 1 after they started. In case of the latter, the effects of the events do not last forever, and they take 0 if their effect is terminated.
An error term is assumed to consist of one-way fixed effect where λ_t is a fixed effect and v_{it}~$iid(0, \sigma_v^2)$.

Table 3: Factors (dummy variables) used for estimation

Time	Dummy	Events
Dec. 2000	d1	Admission of line sharing and dry copper connection charges NTT East and West started its services.
Jan. 2001	d2	ACCA networks started its services.
Feb. 2001	d3	NTT East and West started making the ADSL modem terminal.
Apr. 2001	d4	Revision and enforcement of Telecommunications Business Law Enforcement Rule and connection fee rule
Jun. 2001	d5	Enactment of notification
Sep. 2001	d6	Yahoo!BB started its services.
Nov. 2001	d7	Inauguration of the Telecommunications Business Dispute Settlement Commission
Aug. 2002	d8	Yahoo!BB started the two-month free trial campaign.
Oct. 2002	d9	Yahoo!BB formed a business tie-up with Edion and Joshin Denki.

Source: Author

Data for estimation is an unbalanced panel in which *i* indicates the four carriers of ADSL, and uses monthly data from the end of 2000 to mid-2006. At that time MIC changed the publication of data and monthly data was not published thereafter. The model is based on a log-linear model, where $\beta 1$ shows the elasticity of price. It should be noted that the price data in this equation is that of the highest-speed plan for subscribers, which is normalized into per 1Mbps. Based on the formulation of the demand function, we add a monthly smoothed real GDP, and apply constant dummy variables of factors that are the most important variables of this estimation. The dummy variable shows 0 before the event started, 1 after it started, and 0 if the effects cease.

One of main objectives is to utilize this panel data analysis, and they assume that carriers and times have slope parameters in common. But the elasticity of price may be different from carrier to carrier, as noted in the last chapter. In this case, we can adjust for this, for instance, by adding cross effect terms of price and individual dummy to the model. This is the same as for dummy variables of factors. In this case, however, a serious multicollinearity problem can potentially arise when using all the factors as the cross effect terms. The panel data analysis ordinarily uses hundreds or thousands of data, and it is impossible to estimate the effects on each individual sample.

The previous equation for estimation is based on the “reduced form,” in which factors of both demand and supply are mixed. All the variables are then assumed to be exogenous, except charges. If charges are lowered, then this leads to an increase in the number of subscribers, and this leads to still lower charges simultaneously, since an increase in the number of subscribers reduces costs, and this makes charges lower. Charges are thus considered to be an endogenous variable. To control this, we utilize the instrumental variables method in such a way that charges from one period earlier are taken to be an instrumental variable.

In the random effect model, they utilized the error component two-stage least squares (EC2SLS) method followed by Baltagi [2005], but it was rejected at 10% level by the Hausman test, and thus the fixed effect model was adopted. The elasticity of charges is significant at a 1% level, satisfying the sign condition.

Result of Estimation (Panel Data Estimation)

dependent variable: Subscriber of ADSL											
Fixed Effect IV Model						EC2SLS Random Effect IV Model					
	Coef.	Std. Err.	z-value	p-value			Coef.	Std. Err.	z-value	p-value	
price	-0.4635	0.1021	-4.54	0.000	***	price	-0.3673	0.1097	-3.35	0.001	***
GDP	14.4544	4.0703	3.55	0.000	***	GDP	14.6454	4.4626	3.28	0.001	***
d1	0.6867	0.5442	1.26	0.207		d1	0.5570	0.5986	0.93	0.352	
d3	(deleted)					d3	1.4122	0.0950	14.86	0.000	***
d4	1.5998	0.2954	5.42	0.000	***	d4	1.5507	0.3250	4.77	0.000	***
d5	1.1704	0.2669	4.38	0.000	***	d5	1.1906	0.2936	4.05	0.000	***
d6	1.2913	0.2914	4.43	0.000	***	d6	1.6238	0.3133	5.18	0.000	***
d8	0.6919	0.2414	2.87	0.004	***	d8	1.0784	0.1136	9.49	0.000	***
d10	0.0914	0.1812	0.50	0.614		d10	-0.0289	0.1947	-0.15	0.882	
d11	0.6720	0.1549	4.34	0.000	***	d11	0.5369	0.1693	3.17	0.002	***
d12	0.5412	0.1584	3.42	0.001	***	d12	0.4524	0.1740	2.60	0.009	***
d13	0.1651	0.1297	1.27	0.203		d13	0.1207	0.1427	0.90	0.367	
constant	162.9671	49.7249	3.28	0.001	***	constant	166.2991	54.5022	3.05	0.002	***
	R-sq	within	0.9091				R-sq	within	0.9081		
		between	0.4140					between	0.9363		
		overall	0.7922					overall	0.9122		
F test that all u_i=0		F(3,219)	17.11				Hausman Test	chi2(11)	24.63		
		Prob>F	0.000					Prob>chi2	0.010		
	Number of obs		234				Number of obs		234		
	Number of groups		4				Number of groups		4		

Instrumented: price, Instruments: GDP, d1, d3-d6, d8, d10-d13, price[t-1]

***, **, and * indicate the 1%, 5%, and 10% significant level, respectively.

Source: Author

3.2 Conclusions

The study of broadband demand is usually hampered by both questionable theoretical foundations and lack of price (and service quality) information.

First the results of the study from Moutafides, Economides stiffen the already known positive relationship between broadband lines and income variable as they denote an almost perfect association among them. Same with all goods and services in the end, in the effort of estimating broadband demand, it comes down to price and income and more specifically that price relative to the price of basic needs (food, shelter, etc.). As far as level of education is concerned, demand is affected only by low level educated groups as in most cases persons with higher education are users of innovative services anyhow. Sex is a considerable factor as males influence demand more than females, especially in school ages. They presume that on-line gaming is a key element to the explanation of this phenomenon considering the increasing sales in the gaming machines market. The marital status variable plays quite an important role as singles and widowers/widows have in general more time and money to spend on entertainment (music/video downloads, Internet gaming, etc.), not excluding the possibility of using broadband lines for educational or tele-work purposes.

Next the work of Koutroumpis adds to this emerging field by incorporating a simultaneous approach methodology that endogenises supply, demand and output and provides measurable estimates for impact of the broadband network externalities for the OECD countries. The results suggest that there are increasing returns to broadband telecommunications investments, which are consistent with the persistence of network effects. What has been seen is that there is evidence of a critical mass phenomenon in broadband infrastructure investments. On the theoretical part the level of infrastructure that is required in order to achieve a critical mass cannot always be the same for every country. Perhaps wealthier and more urbanized countries benefit faster from the broadband services because of the economies of scale of the networks. This study acts as a starting point for the macroeconomic impact of fast network access technologies on economic growth. An interesting future study could use data from a global dataset including countries in different growth phases from the OECD core. Richer information and descriptive variables could be incorporated like the way each individual sector benefits from the usage of different broadband platforms and the ways the spillovers are handled and realized.

Also the results of the preceding analysis by Demoussis and Giannakopoulos suggest that observed household heterogeneity does influence the probability of home-computer ownership in any given year. Observed heterogeneity concerns household income, age and education of the husband and wife of the household, number and age of children and the household's predisposition towards technologically advanced durables. In the same context, home computer ownership appears to be affected by the density of installed home computers in the area where the household is situated, a finding that suggests the presence of direct network effects and/or local learning spillovers.

The demographic and economic situation of Greek households (age, education, family composition, income) is not expected to drastically change in the foreseeable future. Therefore, the effect of gradual changes in observed correlates on home computer ownership is expected to be modest.

Rosston, Savage and Waldman empirical results show that reliability and speed are important characteristics of Internet service. The latter finding indicates that very fast Internet service is not worth much more to households than fast service. Willingness-to-pay for speed increases with education, income and online experience, and decreases with age. An interesting finding from their results is that valuations for Internet increase substantially with experience. The implication is that, if targeted correctly, private or public programs that educate households about the benefits from broadband (e.g., digital literacy training), expose households to the broadband experience (e.g., public access) or directly support the initial take-up of broadband (e.g., discounted service and/or hookup fees) have potential to increase overall penetration in the United States.

From the analysis of survey data from Savage and Waldman suggests that household awareness of high-speed service availability is relatively high for cable modem and DSL technology. Preference for high-speed access is apparent among households with a higher income, a college education and multiple PCs.

Finally, Victor Glass, Stela Stefanova results show that while the income effect is positive and significant as expected, the estimates on *Price* and *Speed* are statistically insignificant. That is, after controlling for unobserved heterogeneity and omitted time invariant variable bias, they find no evidence that higher speeds and lower prices alone stimulate demand for broadband. This is not completely unexpected as we use the price and speed information on the base DSL service offered by the company for consistency. As the basic broadband service offered in the rural areas has not changed dramatically over time, the difference scores of price and speed leave insufficient variability in the data between the two time periods and we are not able to precisely estimate their effect on DSL take rates. While they model price and speed for the basic service, demand for DSL may actually be driven by the availability of higher speed products.

Demand for broadband connections increases with the increase of the availability of broadband packages with multiple services. These packages offer in combination with the broadband connection to the Internet and services such as fixed telephony, IP telephony and digital television. The appearance of extra services contributes to the increase of the demand.

In Greece Internet Service Providers offer packages in very low prices during some time periods every year. This has a result to the sales of broadband connections and so the total demand is determined by these periodic bundles, making this way time intervals high or low buying activity. The time period that the phenomenon of offers appear in the Hellenic market are two, the first one at December just before Christmas (Christmas Offer) and the other one in June during the start of the summer period (Summer Offer).

Another use of ADSL service is for remote monitoring and maintenance of large solar power plants (SMA) [36.] A device (webbox) that is connected to the Internet through ADSL connection is responsible for system monitoring, remote diagnosis, data storage and visualization of the efficiency of the photovoltaic system. Its job is the high-performance communication hub for medium- to large-scale solar power plants. It continuously collects all the data from the inverters on the system side, thereby keeping you informed of the system‘s status at any given time.

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Keywords:

- **Broadband:** Transmission technology in which a single medium (wire) can carry several channels at once.
- **ISDN:** Integrated Service Digital Network
- **PSTN:** Public Switched Telephone Network
- **Unbundling:** The obligation the operator – owners of local loops (section of the telephone network connecting the local telephone switch to individual subscribers homes) to provide to a third party operator pairs of bare cooper wires.
- **Retail:** by enabling end-users to purchase high-speed Internet access directly from Internet Service Providers (ISPs)
- **Wholesale:** by providing ADSL access to other operators and enabling them to provide ADSL access and high-speed Internet access directly to customer.