Efficiency of Public Promotions Policies in the Diffusion of Broadband Networks. An Exploratory Analysis.

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ABSTRACT

Extant literature on broadband diffusion at a country or regional level focuses on different research strands. The dependent variable in these works is based on the explanation of the acceptance or the diffusion of broadband networks. Research activity has been focused on the relationship between the supply-side and the demand-side evolution from the point of view of potential users, on the effect of value-added services and technological complements on the diffusion of broadband, and on the benefits that broadband can provide to areas such as education, health services, employment and culture. Finally, research activity can also be found in the influence of technical characteristics or attributes related to specific market segments in countries with greater broadband penetration.

High interest has been spent on the analysis of the deployment of broadband networks in countries with scarce economic and technological resources. In developing countries, information and communication technologies have been postulated as a main drive for economic and social development. Giving access to information and to broadband network infrastructures, digital divide can be avoided and sound steps can be taken to accelerate the technological evolution and to reach higher levels of international competitiveness. Countries with high broadband penetration, like Korea, Japan, Canada, and Scandinavian countries, are good examples of strong economic and social development and they are used as a reference for developing countries.

On the other hand, the commitment of public administration in broadband dissemination forces the promotion of the diffusion of broadband networks through public policies. In this vein, this work analyzes if public promotion policies are a relevant factor in the success of broadband diffusion in specific countries of the European Union and other parts of the world. The main goal is to determine the relationship between diffusion policies and the efficiency in terms of acceptance and use by individuals. This can help public decision makers when issuing new programs or proposing new policies.

The study is based on an empirical analysis of current broadband promotion programs. The work method consists of compiling information about promotion policies. More than one hundred programs have been collected. Compiled information has been classified and standardized in order to homogenize the data and quantitative methods have been applied to perform an exploratory analysis. Macroeconomic data has been included in order to

characterize the behaviour of the countries. Cluster analysis techniques have been used in the exploratory phase of the study. Primary results are outlined in the paper.

KEYWORDS: Broadband public promotion, Broadband diffusion, Cluster Analysis.

Introduction

Some World Bank reports state that information and communication technologies (ICT) generate an opportunity to enhance living standards through the improvement of productivity (Frieden, 2005). Taking this into consideration, few would dispute that broadband development can serve as a powerful agent for economic and social development. Governments and public agencies are focused on enhancing the competence of their nations or regions and therefore they feel motivated to deploy broadband networks for several reasons. From the point of view of their own activity, development of broadband networks allows for the exploitation of e-government and e-democracy applications. At least two consequences can be obtained by widening the spread of these kinds of applications. First, the uptake of networks can be encouraged, and second, the usage cost of the networks for the consumer can de reduced. Considering the external influence, development of broadband networks by government institutions could make the achievement of competitive advantages for public and private organizations easier as well as to accelerate some of the societal challenges that nations need to face in the information age.

Controversially, two paradoxes related to the deployment of broadband networks have to be taken into account. On the one hand, although all countries could accrue for the aforementioned potential benefits, broadband network applications have grown unequally in most of the countries around the world. On the other hand, although a myriad of countries have developed modern broadband networks that allow for fast access to information services from home, broadband subscription rates remain small and vary across countries and regions.

Although this situation can have its roots in a plenty of causes, an important issue that remains unexplored is the role that public administration must play in broadband deployment. Public promotion initiatives issued by national or regional governments have been suggested as one of the key factors in determining the varied penetration rates in the access to established broadband infrastructure. Governmental activities can have a three-pronged orientation. First, legislative or regulatory activities can frame the restrictions that delimit the industry. Second, demand-side stimulation activities can enhance services attractiveness by promoting or aggregating demand. Finally, supply-side stimulation activities facilitate the transition from narrowband to broadband services and promote offers of new services at attractive prices.

Furthermore, the effect of public administration intervention in broadband deployment would not be completed without taking into account that broadband applications and services have been experimenting a two-layer evolution. In the first layer, the perceived value by consumers and companies is based on improving the efficiency of existing narrowband services. In the second layer, broadband network service suppliers should be willing to offer new applications to satisfy new habits or usages within the information age society evolution.

Various factors will affect the success of these future broadband markets. This paper studies the governmental activities that can foster broadband penetration in a country. The argument is that broadband public promotions can provide patterns of behaviour in specific countries or regions and these patterns can guide the launching of new programs or policies in the promotion of broadband development. The main goal is to determine the relationship between diffusion policies and the efficiency in terms of acceptance and use by individuals. This could prove useful to public decision makers when issuing new programs or proposing new policies.

The study is based on an empirical analysis of current broadband promotion programs. More than one hundred programs have been collected from a set of OECD (Organization for Economic Cooperation and Development) countries of the European Union and other parts of the world. Compiled information has been classified and standardized in order to homogenize the data and quantitative methods have been applied to perform an exploratory analysis.

This paper is organized in the following way. In the second section, current situation of broadband networks and broadband diffusion in some countries of the global is analyzed. A literature review on governmental activities to promote broadband dissemination is included. In the third section, the information that have been collected is described. A description of cluster analysis and the method used in the analysis is included. Next section is used to describe the results obtained. Five clusters have been suggested to describe the behaviour of the countries analyzed. Conclusions, further research and references are the last sections in this paper.

Current Situation

BROADBAND DEFINITION

Broadband is a relatively new technology that has changed the way people live and the way society operates as a whole. Broadband is important from the point of view of improvement in the performance of industries and companies. The industry is constantly advancing and

people are finding new ways to use and define broadband. A key feature of future broadband markets is the diversity of access technologies, meaning that numerous technologies can be exploited for broadband communication. (Fredebeul-Krein, 2006). Although, initially Cable and DSL were the predominant technologies, newer technologies like WiFi and WiMax, to name a few, are being used to give high speed access to information age services.

Although the initial definition of broadband was issued by the ITU (International Telecommunications Union) as transmission capacity that is faster than primary rate ISDN (i.e. 1.5 or 2 Mbps), a widely used definition is a minimum threshold for broadband of 256 Kbps for downstream (i.e. data transmissions to the user) and 64 Kbps for upstream (from the user) (OECD, 2004). However, due to the full variety of access networks and transmission devices the term “broadband” should be used flexibly. Therefore, in this work, “broadband” refers to a set of networks devices and communication lines that offer high-speed, high-capacity communication providing Internet access.

At a conceptual level, broadband access presents the benefit of collapsing space and time when it comes to the transfer of information and establishing communication between two subjects anywhere on the globe (Tajiri and Okazaki, 2006). This benefit allows for the transformation and development of the economy and the society in any region. In this manner, broadband can affect businesses, public administration offices, and NGO’s. This transformation can contribute to raising living standards, encouraging individual creativity, realizing a sustainable economic growth and producing a more competitive industry. In OECD (2003) words, "broadband connectivity is considered a key component in development, adoption and use of information and communications technology (ICT). It is of strategic importance to all countries due to its ability to accelerate the contribution of ICT to economic growth in all sectors, enhance social and cultural development and facilitate innovation." Broadband connectivity is therefore increasingly being seen as a catalyst for promoting further economic and social development in this information age.

Broadband penetration in the world offers an uneven panorama. While Korea has ten million broadband users (almost 90% of the Internet users) in the USA 64% of Internet users use a 56Kbit/s modem (ITU, 2003a). Such differences can respond to a plethora of conditionings, as regulatory, market, socio-cultural, and other. Anyway, to develop a sounder Information-

based society broadband is a must.[1] And, therefore, it is not accessory to know the factors that drive broadband penetration and use.

DIFFUSION OF BROADBAND NETWORKS

Coverage has been defined by ITU (ITU, 2005) as the range of a mobile cellular networks measured in terms of geographic coverage (the percentage of the territorial area covered by mobile cellular) or population coverage (the percentage of the population within range of a mobile cellular network). Furthermore, broadband coverage can be interpreted as the percentage of homes that has accessibility to broadband. Most of the countries in our study have a broadband coverage between 80% to 100% (Figure 1). The level of broadband coverage depends on the kind of technology used for its deployment. One hundred per cent of coverage can only be obtained with satellital technology.

To have access to a telecommunications service potential users need to be in a covered zone or area. Then wide coverage is important in order to promote high level of subscription to a service. Data in Figure 1 states that nowadays coverage is not a difficulty in most of the countries that have been included in this study. The level of actual access to a telecommunications service is measured by penetration. Penetration is defined by ITU (ITU, 2005) as a measurement of access to telecommunications, normally calculated by dividing the number of subscribers to a particular service by the population and multiplying by 100.

Although success factors for broadband uptake have been widely analyzed (Tajiri and Okazaki, 2006), empirical studies do not provide conclusive results. On the one hand, the ITU published the fifth Internet Report with a comprehensive analysis of broadband (ITU, 2003a). This report proposes ten factors for broadband success: competition, innovation, application, pro-competitive regulation, price, speed, marketing, high ICT usage, urban demographics and benchmarking. On the other hand, most of empirical studies do not agree with the factors that provide successful outcomes for broadband development. Population density and geographical structure of the country have been stated as a determinant of

[1] "The eEurope Broadband Strategy", Erkki Liikanen, Member of the European Commission, The European Telecommunications Network Operators' Association (ETNO) Conference 'Making Broadband Happen in Europe', December 2002

broadband diffusion (Kim et al., 2003, and Frieden, 2005). Also preparedness (Kim et al., 2003), public policies (Frieden, 2005) and privatization of state-owned operators (Garcia-Murillo and Gable, 2003) have been found as significant variables. Nevertheless price of broadband, income level and competition were not found statistically significant for broadband penetration in some studies (Kim et al., 2003). Otherwise, the same variables were found statistically significant in Garcia-Murillo and Gable's (2003) work. Finally, unbundling was not found to be significant for broadband take-up (Garcia-Murillo and Gable, 2003).

However, broadband dissemination has been questioned in terms of expected benefits (Firth and Mellor, 2005). Firth and Mellor (2005) argue that broadband benefits create a number of complexities that are difficult to understand. Following their arguments, benefits are difficult to identify and to measure and, in most cases, these are confused with the activities that can be performed using broadband networks. Therefore, debate has focused on how to achieve high rates of uptake instead of focusing on in the interest of society (Firth and Mellor, 2005). In this vein, broadband dissemination rate should focus on perceived interest by consumers and organizations.

BROADBAND PENETRATION IN THE WORLD

As it has been stated in previous sections of this work, broadband coverage shows a high level in most of the countries that have been analyzed (Figure 1). Based on this information, most of the countries included in the study have a coverage greater than 80%. Furthermore, penetration in some countries of the OECD has been plotted in Figure 2. The level of penetration ranges from 25 subscribers per 100 inhabitants to less than 10. The most important aspect of this information is that broadband penetration is not correlated to the GDP per capita or other economic and technological indexes of a country. On the other hand, the ratio between broadband penetration and broadband coverage is not uniform (Figure 3).

One of the arguments that explains the difference between the level of coverage and the level of penetration is that broadband networks are not a product by itself but an instrument to get access to other services or to obtain access to contents in the information age (Firth and Mellor, 2005). Moreover, broadband coverage depends on the effort to deploy network infrastructure and penetration depends on perceived utility of services and applications by users or subscribers. Also broadband deployment policies have been based on activities that can be performed using broadband networks, but broadband benefits have been difficult to

understand at individual or organizational level (Firth and Mellor, 2005). Therefore, the evolution of broadband network deployment follows a pace that does not match the evolution of broadband services and applications use.

Reasons that have been used to explain the different diffusion rates in broadband penetration have been classified in three groups: regulatory initiatives, supply side stimulation and demand site stimulation (Frieden, 2005). From the perspective of the governmental economic agents, all three groups of initiatives allow for the deployment of specific policies. Nevertheless, economic policies alone do not explain the different pace of broadband diffusion. A good balance in the mix of legislative measures, regulatory actions and investment decisions by the industry actors have to be achieved (Frieden, 2005). A set of public incentives have to be promoted to foster a sound effort in ICT investment by companies, to cause higher levels of competence between infrastructure providers and between contents providers (Bar et al., 2000).

However, in addition to economic and social benefits, broadband penetration growth also can depend on cultural and social factors that can retard the adoption of services and applications based on broadband infrastructures (Fife and Pereira, 2002). Similarly, ITU (2003) considers that differences in cultures, landscape and technological development are factors that influence broadband demand behaviour.

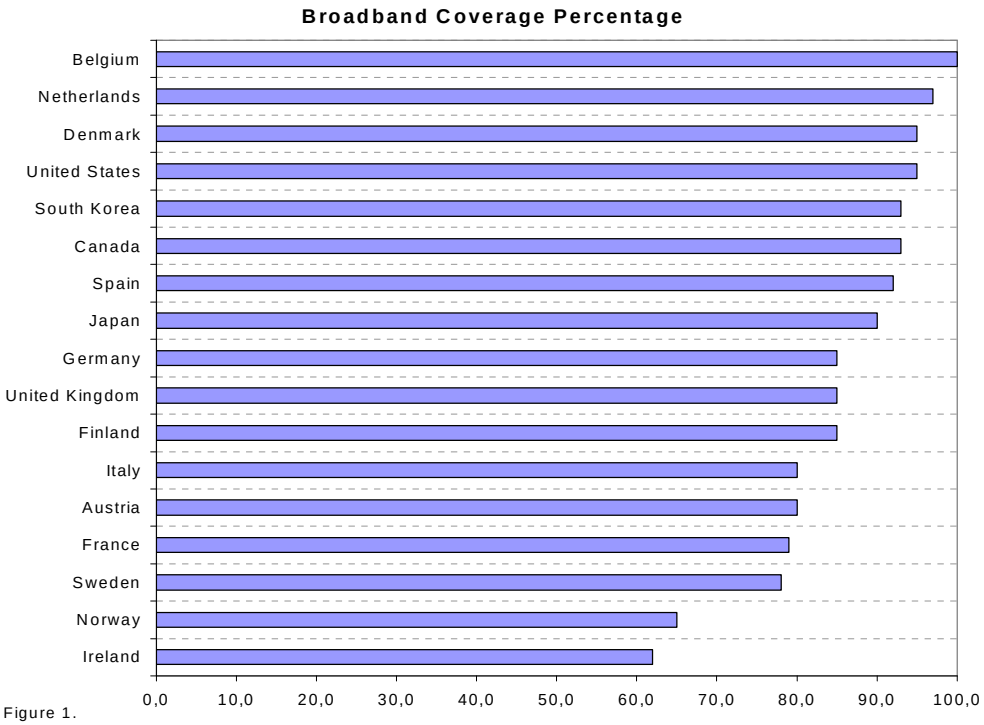


Figure 1.
Source: OECD DSTI/ICCP/TISP(2003)7/FINAL

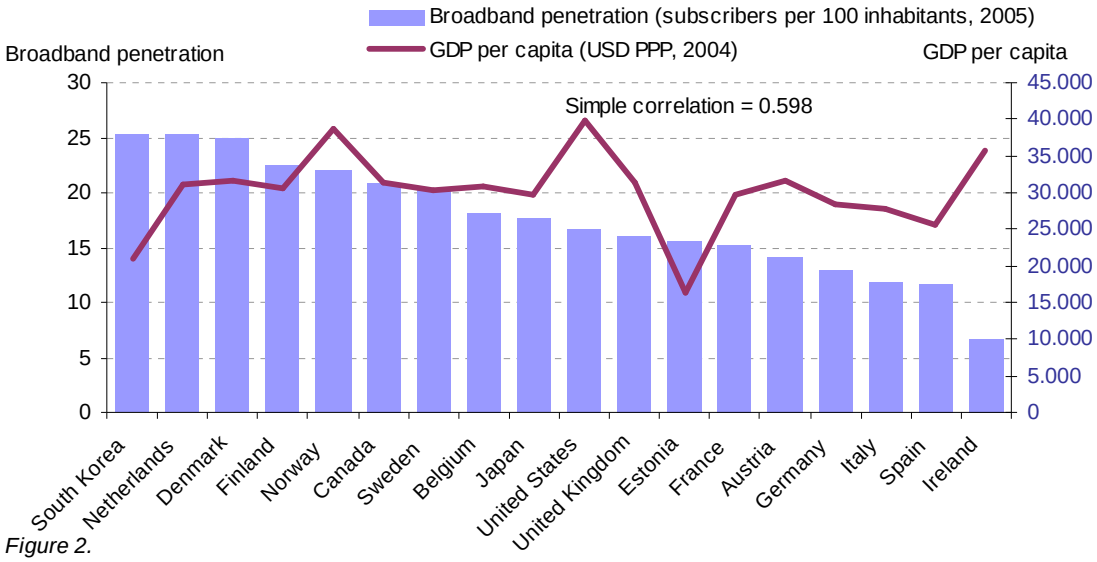


Figure 2.
Source : OECD Broadband Statistics, December 2005

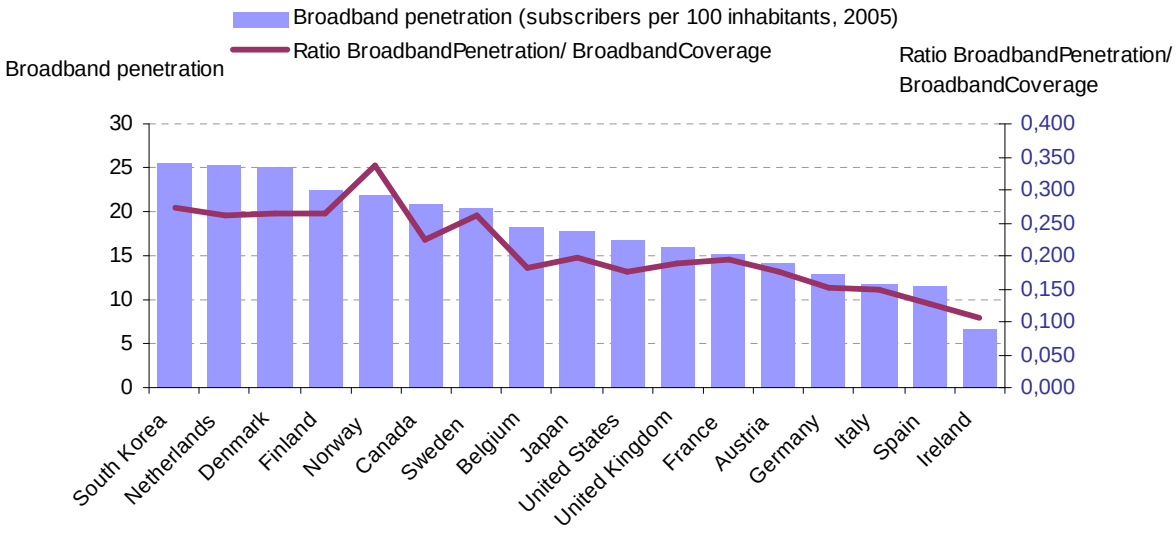


Figure 3.
Source : OECD Broadband Statistics, December 2005

Based on available data (See Figure 1 and 2), broadband penetration offers and uneven outlook on the world, mainly in developed countries. Even more surprising is the lack of correlation between broadband penetration and some of the more important economic variables (GDP per capita and income levels among others) (OECD, 2004; ITU, 2003; Kim et al., 2003). In most of the countries the take-up of broadband has been considered slow (ITU, 2003). Even in countries with high coverage and relatively low prices, broadband demand has remained lower than expected. Republic of Korea has been the most notable exception. Some of the regions in the world are going to be analyzed from the pint of view of broadband

penetration. It looks like consumers do not perceive that broadband access can reach the goals it hyped to.

Republic of Korea shows the highest broadband penetration rate in the world. Almost 25% of inhabitants are broadband subscribers (ITU, 2005). Republic of Korea government has been promoting emerging technologies to take a leadership role in this industry. With the goal to achieve an ubiquitous network society and an industrial competitiveness, the government launched the “IT 839 strategy”. This program focus on developing eight IT services, three primary networks and nine new sectors. Japan is another country making a strong effort in promoting emerging technologies. In this country, broadband penetration rate was almost 15% (ITU, 2005). Japan government strategy is based on the deployment of broadband infrastructure on a nationwide basis and on the advanced ICT usage. Both countries offer a public promotion schema for broadband based on an overall strategy that includes all sectors and actors affected.

In the top ten countries in Europe the average penetration is less than 16%. For all the countries in Europe penetration is less than 6% (ITU, 2005). European Union has been working in promoting and effective deregulation of telecommunication industry. All countries has to have a unbundling local loop policy for 2001 and they work in an ambitious program of broadband for all Europeans by 2010. However, each country has its own broadband strategy that depends on the characteristics of the country.

There has been a strong debate about broadband penetration in U.S.(Keller (2005), Ferguson (2002), Hopkins (2004), Morgan (2002), Turner (2005)). According to the most recent ITU report (ITU, 2005) U.S. is in the 15th position with a penetration rate of less than 13%. This position falls behind its potential situation based on its economic wealth and technological development. Some researchers attribute the U.S. ranking to a lack of a cohesive government infrastructure policy or to geographical characteristics of territory.

Finally, developing countries reflect a bipolar situation. On the one hand some of them boast a relevant position in the ranking of broadband subscribers. Aside of the case of Republic of Korea, some countries have a penetration rate higher than 10%. Among them Hong Kong, Taiwan, Singapore, Barbados and Macao. Most of them are small countries with a high population density and an aggressive economical policy. On the other hand, the rest of developing countries have a very low penetration rate (ITU, 2005).

This situation has been claimed to be worst when broadband diffusion reach higher levels of usage (MIT, 2005). MIT's work states that the current situation is based on a favourable situation from the point of view of subscriber's fee. The main argument is that current users are using existing infrastructures and telecom operators have not been forced to invest in increasing network capacity. If new applications like videoconferencing or other high-capacity consuming applications become popular, telecom operator will have to increase current infrastructure and, based on MIT's report, this will not be possible with the current structure of the subscription fees.

It has been suggested (Grubesic, 2006) that broadband diffusion will follow the familiar "S" curve of innovations. Most of recent innovations as telephone, radio, television and internet have followed this diffusion pattern. However, at a micro level the underlying factors that have been used to explain the conditionings of the diffusion are not clear. Hargittai (1999) was not able to find common factors to explain the deployment of internet among the OECD countries. That study suggest that the wealth of the country, education level or English literacy are not useful in order to explain internet deployment. The same behaviour was found with telephone dissemination. Some countries with a similar technological and economical level had very different patterns of telephone diffusion (Hargittai, 1999).

GOVERNMENTAL ACTIVITIES IN PROMOTING BROADBAND DISSEMINATION

As it has been stated in previous sections, governments are deeply concerned with promoting broadband penetration and use in their nations and regions. Public administration are concerned with two main goals in their effort of development of broadband networks. First, governments want to make broadband access easier and cheaper. To reach this objective, they want to promote a high level of competitiveness in the broadband market. Second, governments want to accelerate broadband diffusion because broadband technology has been suggested as an instrument to enhance economic and social development.

From a more generic point of view, national or regional governments have a strong set of functions in ICT development. Firth and Mellor's (2005) approach to ICT incubation by government lists that successful strategies include activities in the following areas:

- Developing a vision and strategy.
- Promoting digital literacy,

- Investing in infrastructure, aggregating demand and serving as an anchor tenant.
- Fostering facilities-based competition.
- Creating incentives for private investment and disincentives for litigation and other delay tactics.
- Offering electronic government services, including healthcare, education, access to information, and licensing.
- Promoting universal service through subsidies and grants.
- Revising and reforming governmental safeguards to promote a high level of trust, security, privacy and consumer protection in ICT services, including electronic commerce.

Public activities on broadband diffusion have been studied form several perspectives. The primary public activity related to broadband is the regulatory activity of the Telco market. Most of the countries suffered a deregulation process in the basic telephony service some years ago and governmental officers are supervising the evolution of the main communications market. One of the effects of this supervision is the activity related to local loop unbundling (LLU). European countries were involved in this process till 2001, but other countries are still struggling with LLU in order to promote broadband diffusion.

In addition to regulatory and legal aspects, governments can intervene in the supply side of the broadband market. The main actors in the broadband market are network operators, service providers and content providers (Fredebeul-Krein, 2006). In addition, infrastructure roll-out and attractive services/contents provision are the most important activities to be developed. The role of governments in this area can have two different focuses: Promoting competitiveness in both kind of activities, and building public infrastructure (Tajiri and Okazaki, 2006).

As stated in Fredebeul-Krein (2006), governments intervention on broadband markets could be based on the following objectives:

- promote the investment in and deployment of broadband infrastructure;
- encourage the introduction of new and innovative services (health services, electronic commerce, etc.) over the broadband Infrastructure;
- promote the dissemination of and access to diverse content over the broadband Infrastructure;
- ensure that end-users derive maximum benefit in terms of price, choice, innovativeness and quality; and

- ensure that there is no distortion or restriction of competition in the broadband communications sector.

Also, ITU (2003) proposes three different groups of government activities that can affect market structure. The first group is devoted to create a competitive market structure and the action lines in this group are:

- Promoting and maintaining competition
- Regulating the broadband market
- Cross-ownership issues in the broadband market

The second group focuses on activities to promote actors in the supply-side. In this case, the following actions can be issued by governments

- Government frameworks for broadband supply
  - "Light touch" regulation (e.g. New Zealand and Switzerland)
  - Cooperative model: programmes aimed at bridging the digital divide and improving access (e.g. Australia, Germany, United Kingdom, United States)
  - National plans targeted at broadband development (e.g. Republic of Korea, Norway, Singapore)
- Tax credits/low-interest loans
- Government subsidies
- Direct involvement of local government
- Broadband building certification programmes

In the third group, the ITU (2003) includes all innovative broadband deployments that can be promoted from the public administration

- Expanding point of profitability (EPOP)
- Use of existing infrastructure
- Community access points
- Wireless broadband

Finally, governments can act as demand stimulators. Based on information in ITU (2003), key factors found in economies that have been successful in promoting broadband from the point of view of demand-side activity are the following:

- Informing the public about broadband
- Effective use of broadband connections
- Creating an environment that fosters broadband innovation

– Maintaining prices low

Research Method. Data and Methods.

DATA MATRIX

As related in previous sections, public agencies are issuing a set of promotion policies to foster the effect of broadband in industry and economy. The effect of the promotion policies must be based on the effect of a set of different kind of policies. The research goal of this paper is based on an exploratory approach. Our research question focuses on analysing if there are different behaviour patterns in issuing broadband promotion programs. The general aim is that if these patterns can be interpreted and assigned to specific country behaviour profiles they will be useful in determining new promotion programs by public agencies. In the next step the performance of these patterns can be discussed in terms of penetration rate efficiency.

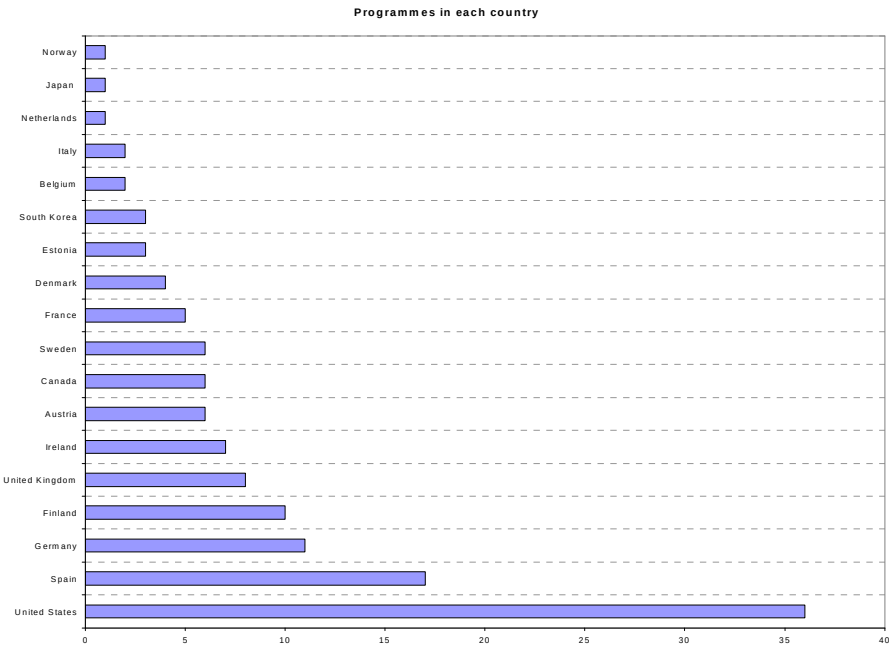


Figure 4.

For a period of two years a set of more than one hundred programs in different countries of developed economies have been collected. Programs have been posted in a website[2] that can be reached at http://teleco.upf.es/poltel. A general description of the programs have been included in Figures 4 and 5.

The programs collected have been classified according the different types of intervention from public administration that have been identified in the literature research. At the first level, three dimensions have been considered significant for the classification of the programs: Overall strategy, scope of action and object of intervention. Overall strategy has been used to qualify each program based on the kind of activity that the program has focused in. Four basic strategies were identified: Demand stimulation, legal and regulatory issues, Infrastructures roll-out and subsidies and financial support. Some of the programs qualified for more than one of these strategies. In a second level of detail, each basic strategy was refined to a lower detail.

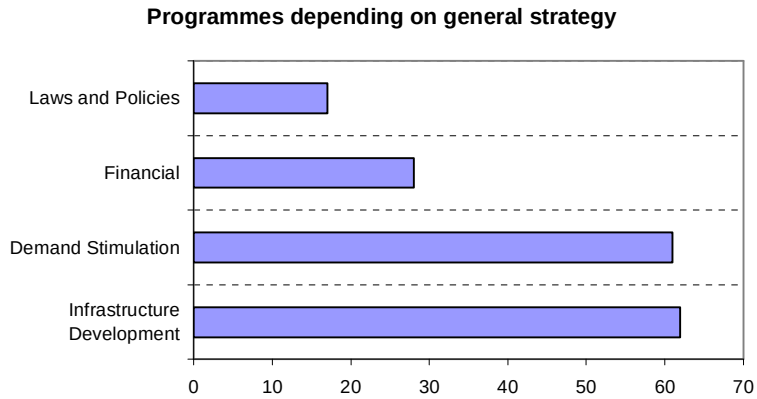


Figure 5.

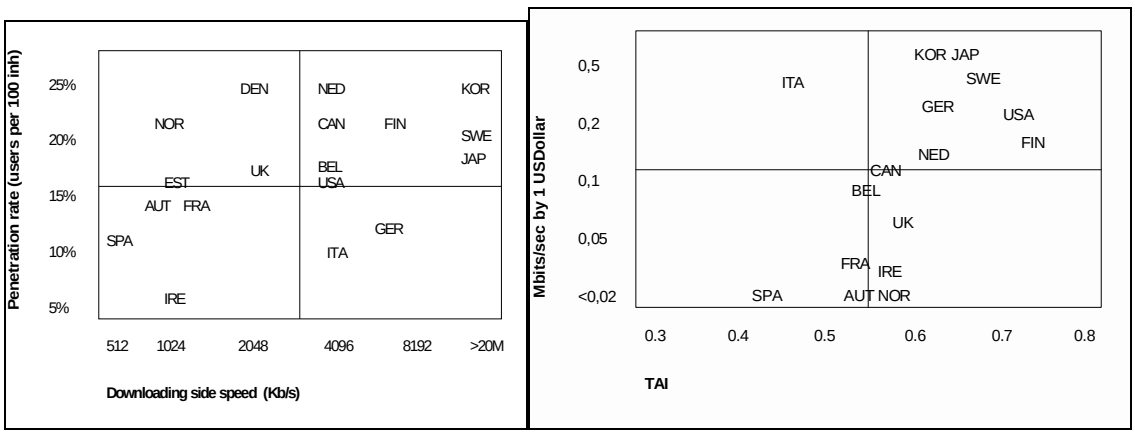
Scope of action was used to distinguish between the different ranges or extent of the activity in the program. Three different scopes have been considered. The geographical scope was used when the program refers to an area or region where the program activity pointed to. Services scope was used to indicate those programs that focused on promoting services. Subjects scope was used to identify those programs devoted to promote broadband diffusion among individuals or institutions.

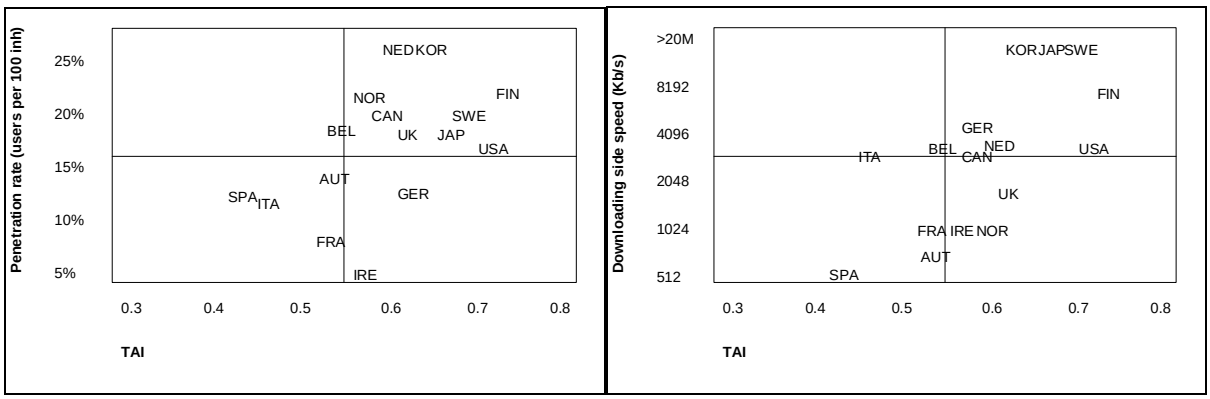
[2] At the time of writing this paper, August 2006, this website is not available in English. More information about these programs can be obtained from the author.

The object of intervention was used to include the kind of broadband infrastructure that was included in the program. Five different objects were identified: rural operators, dark fibre, local or regional networks, wireless network and generic broadband.

Each country has been characterized by the profile of program interventions that have been collected. These different types of interventions have been the independent variables in our analysis. Each variable values the amount of programs within the country that presents this type of intervention. The number of programs in each country and the amount of specific interventions for each program varies greatly. In order to reduce the weight of countries with many programs or the influence of programs with a wide range of interventions, the variables have been rated by the number of programs in each country. In addition, all variables have been standardized (zero mean and unitary standard deviation) in order to have a common space of dimensions. A correlation analysis was performed on the data matrix in order to find overepresented behaviour. Some variables were deleted form the final analysis because they had a crosscorrelation with other independent variables that was statistically significant at 1% confidence level

Furthermore, some independent variables have been included to incorporate the effect of macroeconomic variables or technological development effects. Some specific technological variables that have been included are: Technological Achievement Index, Broadband Penetration rate, Monthly price of a broadband line of 100kbts/sec, and maximum speed in the downloading side. Figures 6 to 9 show the relationship of these variable for the countries included in the study.





Technology Achievement Index (TAI) has been defined as a composite measure of technological progress that rank countries on a comparative global scale (Desai et al., 2002). The index was initially developed for the United Nations Development Programme and was published in the Human Development Report 2001. TAI provides relevant information for policy-makers issuing ICT policies. The index is concentrated in technological outcomes rather than on the effort to create resources to get these outcomes. That means the index is not measuring which country is leading in global technology development, but how each country is creating and using technology (Desai et al., 2002). In the analysis of broadband deployment, the TAI was supposed to have an impact because it focuses on the four dimensions that are important to get the benefits of a networked society (Desai et al., 2002). The first dimension is based on the innovation or creation of technology. This dimension measures the capacity to innovate in the use of technology for each country. The second dimension is based on the diffusion of recent innovations. This dimension is measured by the level of diffusion of the Internet and by exports of high-technology and medium-technology. The third dimension accounts for the diffusion of old innovations. It assumes that technological advancement is a cumulative process, and widespread diffusion of consolidated technologies is necessary for adoption of newer ones. Finally, the last dimension is the level of human skills that have been developed in the country. Basic education and tertiary education are the founding parameters to assess this dimension (Desai et al., 2002).

Some other technology indexes can be found in the literature (Furman et al., 2002 and Archibugi and Coco, 2004) but most of them are highly correlated with the TAI (Archibugi and Coco, 2005). The rest of the independent variables, penetration rate, monthly price of broadband lines and maximum speed in the downloading side have been obtained from the most recent ITU report (ITU, 2005) and compared to available data from OECD.

CLUSTER ANALYSIS

To perform the exploratory analysis, multivariate methods have been used. The objective of the so-called multivariate methods is to find relationships within a data matrix. Considering these methods, a distinction can be made between dependent and interdependent methods. Interdependent methods deal with all variables simultaneously and equally. Specifically, cluster analysis comprises interdependent techniques for classifying objects described by sets of values of several variables. Cluster analysis techniques can be regarded as successful if the interpretation of the clustering produced is made clearer than the initial data matrix structure (Alt, 1990 and Spath, 1981).

Clustering methods can be classified between heuristic methods and hierarchical methods. Heuristic methods are oriented towards geometric representation of cluster groups of points around centroids that minimize the average distance to these centres. Hierarchical methods are based on strategies that either all objects are taken together as one cluster and new clusters are produced by division of some or all of those so far produced or objects are united into clusters step by step.

Heuristics (or iterative partitioning) methods (Alt, 1990) are mainly used in trying to identify clusters of objects in terms of the characteristics they share in common. On the other side, hierarchical (agglomerative or dendogram) methods (Alt, 1990) produce non-overlapping clusters that are nested in successive larger clusters at higher levels of similarity.

In this analysis the K-means algorithm has been used (Spath, 1981). The K-means algorithm is a heuristic clustering method that is stepwise optimal. As a starting point, this algorithm needs to know the number of groups that are desired. The result obtained is the optimal grouping of the individuals within the specified number of groups. In previous works, cluster analysis with a K-means method has been used to study the diffusion patterns of IT innovations (Teng et al., 2002) and to classify telecommunications innovations in Korea (Kim and Kim, 2004). In our case. cluster analysis was conducted to explore options of grouping the countries based on the profile of the public promotion programs in each country. The SPSS (version 11.5) software was used to perform our analysis.

In order to proceed with the analysis of the broadband promotion policy programs we have used a sequential refinement process. Each result has been validated based on the interpretation of the obtained groups. Initially, the analysis was performed for a grouping of

two clusters. In a successive refinement process, the number of clusters was incremented in one unit. Each new cluster was interpreted based on the characteristics of the countries included in the clusters. In this process, some clusters maintained their initial structure and others have adapted their composition following the characteristics of the countries within the cluster.

Results

In this exploratory analysis the most significant results shows that country behaviour on broadband public promotions can characterized by five clusters of countries. All the patterns can be explained by the profile of the broadband public promotion programs that each country has issued and by some technological variables. Although some clusters are consistent other depend on the variables included in the analysis.

Cluster 1. Information age services. This cluster is composed by the Scandinavian countries: Denmark, Norway and Finland. All three countries have a high technological development and broadband penetration is among the highest in the world. The main characteristic of these countries is that broadband public promotion programs are focused on providing services in the information age. Although governments in these countries have not been issuing programs to develop infrastructures, all economies within this cluster have a sound broadband network and a consolidated position in the technological achievement index ranking.

Cluster 2. Demand stimulators. Most of the countries have made efforts to launch initiatives related to the market side of the broadband industry. Countries in this cluster have concentrated their promotion activities in stimulating the demand side of the industry. A complementary effort in promoting infrastructure deployment is also relevant in this cluster profile. Sweden and Italy are the two countries that make up this cluster. From the point of view of broadband penetration and technological level both countries exhibit different profile. Sweden is in the high end of both rankings and Italy is in the low end within the countries included in the analysis. Therefore, technological development is not a distinctive variable in this cluster.

Cluster 3. Financial support for local and rural networks. A third cluster is composed of countries that have a relatively high technological index. Form the point of view of the

strategy, the greater number of programmes in these countries are devoted to give financial support to broadband diffusion. Financial support can be through subsidies or through low-interest loans. The second characteristic of the programs in this cluster is based on the object of intervention. Countries in this cluster have an important number of programs that try to improve broadband penetration through rural networks or through local or regional networks. In addition to the common characteristics, each country within the cluster has a specific behaviour in some other dimensions of the data matrix. Republic of Korea has emphasized a strategy based on infrastructure deployment, on the other hand, United States have focused on specific subject for the scope of the programs, and, finally, Austria has issued programs to support the delivery of e-services.

Cluster 4. Infrastructure developers. The countries in this cluster have concentrated their promotion efforts in developing broadband infrastructures. All of the countries have a very high technological achievement index and a high GDP per capita. The penetration rate is not homogeneous within the cluster. The Netherlands have one of the highest penetration rates in the world and, on the other hand, Ireland has one of the lowest in the set of countries of this study. Another common characteristic within the cluster is the object of the intervention. Most of the countries in this cluster have launched programs that are devoted to a specific objects. For example, Canada, Ireland and France has had a strong activity in rural operator and in dark fibre infrastructure. Moreover, France, Germany and Japan have a lot of programs in promoting local or regional networks. Also, Ireland and The Netherlands have programs to promote WiFi networks. None of the countries has programs that focus on promoting broadband from a generic point of view.

Cluster 5. Subject-oriented countries. A program has been classified with a scope of “subject” when the activity of the program focuses on giving support to a specific group of citizens, institutions or companies in a country. The fifth cluster is made up of countries that have a strong concentration in programs related to give support to specific subjects. This is the case of Belgium that has programs to support cancer patients in a e-Health initiative. Also, in Spain and Estonia there are programs to provide Internet broadband connection in primary school centres. And finally, regional governments in the UK have issued programs to subsidizes companies that want to use broadband networks.

The main characteristics of each cluster and the countries that have been included have been summarized in Table 1.

TABLE 1	Cluster 1. Information age services	Cluster 2. Demand Stimulators	Cluster 3. Financial support for local and rural networks	Cluster 4. Infrastructure developers	Cluster 5. Subject-oriented
Countries	Denmark, Norway, Finland	Sweden, Italy	Austria, Republic of Korea, USA	Germany, Canada, France, The Netherlands, Ireland and Japan	Belgium, Spain, Estonia, UK
Technological level	High TAI, and High penetration	No specific common characteristics	High TAI	High TAI High GDP	No specific common characteristics
Promotion programs characteristics	Providing services for the information age	Promoting demand stimulation Deployment of infrastructures	Promotion of rural and local initiatives Funding programs	Deployment of infrastructures Specific objects	Giving support to citizens, institutions or companies.

Two groups of cluster have been identified. In the first group, programs emphasize broadband infrastructure deployment in the second group other aspects of broadband promotion are supported.

Clusters 4 and cluster 3 are members of the infrastructures group. Cluster 2 has characteristics of both groups. Finally, clusters 2 and 5 belong to the second group.

Conclusions

The final outcome of this work is that different country behaviour have been identified when issuing broadband public promotion programs by regional or national government or public institutions.

Five main clusters have been identified in this exploratory analysis. Each cluster is composed of a set countries with a specific profile in issuing broadband public promotion programs. Each cluster shows a specific country behaviour in issuing broadband public promotion programs. It is out of the scope of this work to interpret the specific traits of each cluster and establish the relationships of each cluster with the policies of each country.

The main outcome of the study is that a set of cluster have been obtained and that the interpretation of this clusters has been compared to the behaviour of the countries in broadband public promotion. Each cluster shows a progressive or evolutionary behaviour of the countries. Cluster 1 shows the behaviour of countries with a solid network infrastructure. They are motivated to increase the number of applications performed in a broadband

network. It looks like they are not worried about the infrastructural aspects and they are more concentrated in increasing the number of services or applications provided through the broadband network.

Cluster 2 includes countries with a double strong interest. They are issuing programs to develop infrastructure and also to stimulate the demand of broadband services. Both countries have a high coverage but a heterogeneous penetration. An in-depth analysis should be needed in order to clarify this situation.

Cluster 3 and cluster 4 show to behaviour that can be considered in two different ends. Cluster 3 is focused on providing financial support for local and rural networks and cluster 4's focus is on developing infrastructures for some specific broadband objects, including local and rural networks. It should be analyzed the different outcomes in the countries of each cluster.

Finally, cluster 5 shows a behaviour related to a different focus of the rest of the clusters. It is not clear if this behaviour could be applied to other countries or regions.

Limitations and future steps

Some limitations have to be taken into account when reading the results of this study. First of all, the programs included in the study are not exhaustive. The programs have been collected, for a period of two years, from the web and other institutional sources and we can not be sure that all programs have been collected. On the other hand, the study has been restricted to some developed countries. One further step should be to increase the number of countries included in the study.

On the other hand, this study has been considered a preliminary work. Clusters found have not been analyzed form the conditioning characteristics of each nation. Next steps should be to make an in-depth analysis of the structure of the cluster and the underlying factors within each cluster. Some factors could explain the composition of each cluster. For example, the political structure of each country or the previous history in ICT development of each nation. To complete the analysis of the underlying factors a principal component analysis at a program level could be used.

In the previous section, some new paths of work have been proposed. These lines could be used to propose theories of behaviour that could be analyzed through a theory using a confirmatory analysis. In this vein, the exploratory study that has been performed can be used as a preliminary step in the formulation of theories.

Bibliography

Alt, M., 1990. *Exploring Hyperspace*. McGraw-Hill Book Company, London, England, 1990.

Archibugi, D. And Coco, A., 2004. A new Indicator of Technological Capabilities for Developed and Developing Countries (ArCo), Worl Development, 32(4), 629-654, 2004

Archibugi, D. and Coco, A., 2005. Measuring technological capabilities at the country level: a survey and a menu for choice, Research Policy, 34(2), 175-194, 2005.

Bar, F., Cohen, S., Cowhey, P., DeLong, B., Kleeman, M., & Zysman, J., 2000. Access and innovation policy for the third-generation internet. Telecommunications Policy, 24(6-7), 489-518.

Desai, M., Fukuda-Parr, S., Johansson, C., and Sagasti, F., 2002. Measuring the Technology Achievement of Nations and teh Capacity to Participate in the Network Age, Journal of Human Development, Vol. 3, No. 1, 2002.

Ferguson, C.H. 2002. The U.S. broadband problem. The Brookings Institution, from http://www.brookings.edu/comm/policybriefs/pb105.htm, accessed August 31, 2006.

Fife, E. and Pereira, F. 2002. Socio-Economic and Cultural Factors Affecting Adoption of Broadband Access: A Cross-Country Analysis. 41st European Telecommunications Congress, Genoa, Italy, 11-14 Sept, 2002.

Firth, L., and Mellor, D. 2005. Broadband: Benefits and problems. Telecommunications Policy, 29(2-3), 223-236.

Fredebeul-Krein, M., 2006. Developing Competitive Broadband Markets: Lessons Learnt from German and European Regulatory Approaches on Broadband Access. International Telecommunications Society, 16th Biennial Conference, June 12-16, Beijing, China, 2006.

Frieden, R. 2005. Lessons from Broadband Development in Canada, Japan, Korea and the United States. Telecommunications Policy, 29(8), 595-613, 2005.

Furman, J.L., Porter, M.E., and Stern,S., 2002. The Determinants of National Innovative Capacity. Research Policy, 31 (6), 899-933, 2002.

Garcia-Murillo, M. and Gabel, D., 2003. International Broadband Deployment: The Impact of Unbundling, 31st Research Conference on Communication, Information and Internet Policy, Arlington, VA, USA, September 2003.

Grubesic, T.H., 2006. A Spatial Taxonomy of Broadband Regions in the United States. Information Economic and Policies. In press, corrected proof available, July, 2006.

Hargittai, E., 1999. Weaving the Western Web: Explaining Differences in Internet Connectivity among OECD Countries. Telecommunications Policy, 23(10-11), 701-718, Nov, 1999.

Hopkins, J. 2004. Other nations zip by the USA in high-speed net race., USA Today, 2004 from http://www.usatoday.com/tech/techinvestor/2004-01-19-broadband_x.htm, accessed August 31, 2006.

ITU, 2003. Promoting Broadband: Background paper. Workshop on Promoting Broadband, International Telecommunication Union, Geneva, April 2003.

ITU, 2003a. ITU Internet Reports. Birth of Broadband. International Telecommunication Union, Geneva, 2003.

ITU, 2005. ITU Internet Reports. The Internet of Things. International Telecommunication Union, Geneva, November 2005.

Kelley, R., 2005. Broadband lag could hurt the U.S. Retrieved August 31, 2006, from http://money.cnn.com/2005/06/16/technology/broadband/index.htm

Kim, J. H. , Bauer, J. M., Waldman, S. S., 2003. Broadband Uptake in OECD Countries: Policy Lessons from Comparative Statistical Analysis, 31st Research Conference on Communication, Information and Internet Policy, Arlington, VA, USA, September 2003.

Kim, M.-S., and Kim, H., 2004. Innovation Diffusion of Telecommunications: General Patterns, Diffusion Clusters and Differences by Technology, in International Journal of Innovation Management, vol.8: World Scientific Publishing Company, 2004, pp. 223-241

MIT, 2005. The Broadband Incentive Problem. Broadband Working Group. MIT Communications Futures Program (CFP), September, 2005. http://cfp.mit.edu/groups/broadband/docs/2005/Incentive_Whitepaper_09-28-05.pdf, accessed August 31, 2006.

Morgan, G. 2002. Gates warns US lags behind in broadband, from http://www.vnunet.com/vnunet/news/2117463/gates-warns-lags-behind-broadband, accessed August 31, 2006.

OECD, 2003. Organization for Economic Cooperation Development (OECD), Broadband Driving Growth: Policy Response, October 2003. http://www.oecd.org/dataoecd/18/3/16234106.pdf

OECD, 2004. Organization for Economic Cooperation Development, Benchmarking Broadband Prices in the OECD, DSTI/ICCP/TIPS(2003)8/FINAL, 2004.

Spath, H., 1980. Cluster Analysis Algorithms. Ellis Horwood Lt, West Sussex, England, 1980.

Tajiri, N. and Okazaki, T., 2006. Policies for Broadband Diffusion in Developing Countries, International Telecommunications Society, 16th Biennial Conference, June 12-16, Beijing, China, 2006.

Teng, J. T. C., Grover, V., and Guttler, W. 2002. Information technology innovations: General diffusion patterns and its relationships to innovation characteristics. IEEE Transactions on Engineering Management, 49(1), 13-27, 2002.

Turner, S.D. 2005. Broadband reality check. the FCC ignores america's digital divide, Free Press, 2005.