

VERY FIRST DRAFT

**NETWORK NEUTRALITY VERSUS NETWORK DIVERSITY AND BROADBAND  
DEPLOYMENT IN OECD COUNTRIES**

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## **1. Introduction**

Based on available data, broadband penetration offers an uneven outlook on the world, mainly in developed countries (Papacharissi and Zaks, 2006). 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 countries, broadband take-up 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 (Papacharissi and Zaks, 2006).

It has been claimed that this situation is worse when broadband diffusion reaches 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 the 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 operators 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 (Grubestic, 2006) that broadband diffusion will follow the familiar "S" curve associated with innovations. Some recent innovations such 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 suggests that the wealth of the country, education level and English literacy are not useful in order to explain internet deployment. Telephone dissemination followed the same pattern. Some countries with a similar technological and economical level had very different patterns of telephone diffusion (Hargittai, 1999).

On the other hand, the diffusion of broadband networks can be analyzed from the perspective of the diffusion of technological innovation and the economics of technology adoption (Papacharissi and Zaks, 2006). It has been proposed that a combination of lock-in and switching costs has reduced the adoption rate of Internet broadband connection. Both consumers and access providers have been experiencing very high costs to speed the upgrade from narrowband Internet access to broadband. Moreover, consumers have been affected by the principle of relative constancy (Papacharissi and Zaks, 2006), “the only way to get consumers to adopt a newer medium is to give them reasons to abandon an older one”. The main idea is that consumers can only spend a fraction of their income on Internet services. In addition, Papacharissi and Zaks argue that the present broadband content does not act to persuade consumers to adopt broadband access. Finally, in most countries, infrastructures are not adequate to provide high quality broadband services.

In this work, we analyze the situation of broadband networks in several OECD countries and propose to study the net neutrality debate from the point of view of the evolution of broadband penetration and the public broadband promotion. We postulate that in most of the countries the network neutrality debate will depend, among other dimensions, on the broadband penetration rate. The saturation of the broadband network and the need to face new investments to upgrade the infrastructures are going to force a solution on the net neutrality debate.

Regulators can be exposed to three extreme positions. In one end, consumers can be reluctant to use new applications and services if the network performance is low and if the network cannot be used in a free manner with the new high consuming broadband applications and services. On the other end, content providers can find their new applications and services difficult to adopt by end-users if these services cannot run in a high-performing network. Finally, network operators could be deterred from starting new investments if their business plans are not financially sound enough. They would not be willing to upgrade the network infrastructure if they cannot assure a short-term benefit from the new features of the network.

In this paper, we try to focus on the parameters that influence the ecosystem that subscribers, content providers and network operators must balance. In section 2, we propose a multidimensional approach to the net neutrality debate. Our aim is to show that there are several perspectives that can be used to illustrate the net neutrality problem. We focus on the dimension around the axis of broadband penetration to study how the penetration rate in a specific country can influence the net neutrality regulation. In section 3, we describe some patterns in broadband public promotion within OECD countries. Using cluster analysis, five behaviour patterns have been observed that model the broadband promotion activity. In Section 4, we have studied the broadband penetration rate of all OECD countries and we propose a set of models based on the characteristics of the evolution of broadband penetration. In section 5 we outline the set of scenarios that can be deduced from the two previous steps and relate these scenarios to the main dimension of the network neutrality debate that are relevant in our analysis. Finally, in section 6 some conclusions are drawn, limitations are framed and future steps are proposed.

## **2. Net Neutrality perspectives to encompass this work goal**

### 2.1 Towards a definition of net neutrality

As it has been postulated, one of the main problems of the net neutrality debate has its roots in the lack of a precise definition (Peha, 2006, Lehr et al, 2006). This lack of definition generates many different parallel debates around the net neutrality concept. Therefore, all these debates produce a plethora of discussion fora that reduce the possibility to converge to a unified line of progress in the debate. Consequently, the multidimensional characteristics that underlie this debate contaminate decisions about net neutrality regulation. On the other hand, net neutrality originated in the US as a regulatory matter but its main goal is to get an agreement about how the Internet and the telecommunications market must evolve in the following years. This places the debate among many different actors (regulators, network operators, network users, content providers, ISP) with a set of contradictory interests among all of them.

Most of the definitions proposed for net neutrality work around two main axes (Bauer, 2006, Wu, 2003)

- Preserving the openness of the Internet so that consumers and content providers can freely access the network in order to access or to provide applications and services
- This access or provision must be done without the fear that the broadband network provider could deteriorate or degrade the application and services

Proponents of net neutrality argue that the Internet has always been neutral and they claim that newer telecommunications infrastructures must maintain this freedom (Roycroft, 2006). The main argument to support their position is that net neutrality regulation will produce a bunch of applications and services innovations that are going to produce a big economic growth, as the Internet did in the last fifteen years. Conversely, proponents of net diversity remind us that the Internet has been neither neutral nor egalitarian (McTaggart, 2006). Some examples include the fact that in some countries there are some applications that cannot be freely run in the Internet (Wu, 2003). For example, Virtual Private Networks (VPN) cannot be run in some networks in the US. Another example that affects the neutrality of the network is the fact that in most countries network operators can act as ISP in the DSL or cable network. This vertical integration might reduce the freedom of the end-users. McTaggart (2006) proposes five groups of examples that cast significant doubt on the neutrality of the commercial Internet. Namely these groups are: preferential content arrangements, distributed computing, control of network abuse, interconnection and interconnectivity, and resource-intensive content and applications. In each one of these groups, the author explains some examples that illustrate the lack of neutrality or egalitarianism within the Internet. The main source of neutrality in the Internet comes from the transport protocol (TCP/IP) but it is difficult to generalize this behaviour to the rest of the network layers. Finally, the discussion on the neutrality of the narrowband Internet includes such opinions as “the neutral platform was developed by accident rather than design” (Bauer, 2006), “non-neutrality is common and may be necessary to serve user interests” (Wu, 2003), and “the evolution of the Internet and the user demands will make it necessary to maintain a non-neutrality approach” (McTaggart, 2006).

If the narrowband Internet is not neutral, what are the fears of net neutrality proponents in the broadband Internet? Why do they demand net neutrality regulation? At least three main lines of interest feed these fears. Firstly, technical characteristics of network elements allow network operators to inspect packets and make decisions (like price differentiation or application prioritization or bandwidth management) based on their content (Peha, 2006). Secondly, digital convergence will increase traffic and will open the network to new broadband applications and services (van Schewick, 2007). Finally, the traditional business of network operators (transport of telephone voice calls) is dwindling and they need to look for other income sources (Wu, 2004). These three lines combined put operators in a good position to take stronger control of the network operations and reduce the transparency of the network traffic. Network operators can implement their new vision with a combination of taking profit of the characteristics of the network elements, changing some of the architectural principles of the Internet, and proposing new alliances with their partners in order to propose new business models in the telecommunications market.

From the perspective of net neutrality proponents, net neutrality rules would have to forbid all three kinds of interventions. Controversially, all three could be used to increase users' welfare (Peha, 2006) and to reduce market power positions (Wu, 2004). This makes it difficult to reach a decision accepted by all parties and leads to pursue a regulation whose main goal would be to avoid anticompetitive conduct from network operators. The main problem of this regulation is that if the anticompetitive regulation is too strong, network operators can be forced into commoditizing broadband transmission. If this is the case, giving the economic characteristics of local communications network, policies that promote commoditization of broadband access could lead to the monopoly provision of advanced broadband services in many markets (Ford et al, 2006). This outcome would harm consumers substantially. On the other hand, if network operators cannot obtain some rents from network operation they are not willing to do the necessary investments to upgrade the network. Moreover, with a strong anticompetitive regulation, network operators can be pushed to a fier concentration in the last mile producing a kind of vertical integration that would reduce the options for the end-users in the access market (Yoo, 2006). Finally, some source of market failure (as the tragedy of the commons) has been advised (Yoo, 2006).

Within this position a wide spectrum of regulation, from a minimum level of constrain to a maximum level of constrain, can be proposed. The minimum level would be similar to a basic antitrust approach, full freedom providing they do not violate any competition law. The maximum level of constrain would establish a specific regulation for all market variables. Regulators have to locate their regulatory pointer in a position that constrain but do not impede network operators to discriminate (Bauer, 2006).

## 2.2 A balanced policy on net neutrality

Unfortunately, the net neutrality debate remains open. Although many efforts from the economic field have been reported, there is a wide consensus on the fact that researchers are finding many difficulties in obtaining an economics of neutrality (van Schewick, 2007, Kocsis and de Bijl, 2007). Based on this situation, there is not a convergence stream of opinion that groups the variety of positions and most of them are active in this debate. In the following paragraphs, we expose a discussion on the most important positions in the net neutrality field and describe the main axis of the debate.

*Openists.* This term was coined by Tim Wu (Wu, 2004) to include proponents of a strong net neutrality regulation. The main idea that guides this opinion's group is that broadband application and services innovation is going to produce a big economic growth as it happened some years ago with narrowband Internet. The glossy lemma for this group is that "innovation is going to be produced at the edges". From their point of view, network competition should happen at the infrastructure level and network operators should avoid competing using application and transport levels together.

The proposals of the net neutrality regulation proponents are that the Internet must maintain its current architectural layers and that network operators cannot interfere in application operations. Based on these proposals they argue that to assure network competition regulators must propose rules to assure that competition is

possible at the infrastructure level. Finally, from their perspective, network upgrading must take place based on public investment.

*Network Diversity.* The main concern of net neutrality opponents is that the net neutrality regulation can have the effect of “commoditizing” broadband services. This could happen if network operators were not allowed to differentiate their service offerings from the rest of rival firms (Ford et al, 2004). In addition, although network operators are not against a net neutrality policy to prevent anticompetitive conduct, they want to have the possibility to explore new income sources based on the new features that communication technologies are providing. These two claims together configure what has been called “Network Diversity”.

On the other hand, net neutrality proponents base their arguments on the economic theory of product differentiation (Frieden, 2006). If network operators can differentiate their products, more competitors will be willing to enter into the broadband network market and a less concentrated industry structure would take place. This situation would be beneficial for end-users and would increase consumers and society welfare. Moreover, network operators need new income sources in order to support their business cases. Except they can propose a financially sound business plan, they are not willing to invest to upgrade network infrastructure. If broadband network were not upgraded, network performance would be degraded by the new high bandwidth demanding applications and services.

*Balanced Policy.* As it has been stated before, net neutrality regulation is very difficult and some authors suggest that it is going to be difficult to implement it in the near term (Lehr et al, 2006). The major difficulty comes from the fact that both ends of the debate propose important arguments that have to be implemented. Unfortunately, some of these proposals are incompatible from the point of view of end-users welfare. In this vein, a balanced policy has been proposed that includes a policy to protect beneficial uses of discrimination and to limit its harmful uses (Peña, 2006).

This author's proposal stands to prevent the most harmful cases that network discrimination can produce. Based on this work reasoning, a balanced policy would have to take into account that discrimination should not be seen as inherently harmful (Peha, 2006). First, it is necessary to discern between discrimination and differentiation (Lehr et al, 2006). Secondly, some forms of discrimination can be beneficial for a net neutrality regulation (Wu, 2004). Finally, discrimination is only a problem if net operators misuse their market power (Peha, 2006).

*A deregulationist Net Neutrality.* Tim Wu (Wu, 2003) proposes to face the net neutrality debate from the point of view that net neutrality is an end in the desired evolution of the Internet. To reach this end, Wu argues that the diversity of approaches for the net neutrality debate are means that try to solve the question. With this reasoning in mind, Wu analyzes the major approaches in the net neutrality debate and argues how they favour to achieve the net neutrality goal (Wu, 2003). The argument for net neutrality as the end of the Internet evolution can only be understood within the framework of the evolution models for innovation. These models state that innovation is produced in a competition among technology creators. Consequently, if the Internet must maintain its platform open for innovation, it is mandatory to be neutral among end-users (Ziman, 2000). Furthermore, some proposals from the open access proponents have shown to be counterproductive to achieve the main goal (Wu, 2003). In addition, network discrimination based on a self-regulation approach is not appropriate because network operators can hardly manage to distinguish between short- and long-term interests. Finally, this author (Wu, 2003) proposes to establish a regulation based on network discrimination that prevents network operators to apply discrimination rules harmful for end-users.

### 2.3 The focus of our work on Net neutrality

Although both sides of the debate are interested in innovation and open market entry (Wu, 2004), the most important argument of each side is located at different levels. Net neutrality

proponents are principally concerned to get an “open access” network (that is to say, the “end” of the debate) and net neutrality opponents want to avoid governmental interference (that is to say, the “means” of the debate). This dispersion on the level of the debate and the multidimensional characteristics of the net neutrality problem suggest proposing a clear delimitation of each dimension in order to clarify the debate object.

The proposal of a balanced policy (Peha, 2006) and the intent to get a net neutrality position through deregulationist means (Wu, 2003) are good examples of the unbalanced levelling of the debate and the need to encompass a plethora of characteristics in this complex matter. Two main axes drive our research. The first one is that net neutrality has to be seen as a multidimensional problem and therefore it has to be expressed from the perspective of each dimension. Net neutrality proponents and opponents can use each dimension of this debate for and against their point of view. The second axis takes one of the debate dimensions as its justification argument: Broadband penetration rate in each country will condition the development of the net neutrality debate.

### 2.3.1 A multidimensional perspective of net neutrality

In this part of the paper, we are interested in highlighting some of the dimensions of the debate. Each dimension can be analyzed with the arguments that are used in the two ends of the debate and with the threats that each end foresee in the rival’s position. It is out of the scope of this paper to elaborate a deep analysis of each dimension (van Schewick, 2007, Sidak, 2006, Kocsis and de Bijl, 2007, Frieden, 2006, Bauer, 2006, Peha, 2006, Wu, 2004). Nevertheless, a non-exhaustive list of the main dimensions that have been isolated from the literature review for this work can be found in Table 1.

### **Net Neutrality Dimensions**

| Dimension label | <i>Proponents’ main position</i> | <i>Opponents’ main position</i> |
|-----------------|----------------------------------|---------------------------------|
|                 |                                  |                                 |

|   |  |  |
|---|--|--|
| <b>Access Control</b>                   | <i>Free Access</i>                             | <i>Access Tiering</i>                        |
| <b>Innovation</b>                       | <i>Innovation at the edges</i>                 | <i>Innovation at the core</i>                |
| <b>Vertical Integration</b>             | <i>Dumb pipe</i>                               | <i>Facilities-based competition</i>          |
| <b>Classes of applications</b>          | <i>Best effort</i>                             | <i>Bandwidth management</i>                  |
| <b>Investment and Network Upgrading</b> | <i>Public Network</i>                          | <i>Private Network</i>                       |
| <b>Architectural vision</b>             | <i>Plain packet network</i>                    | <i>Specific treatment for each packet</i>    |
| <b>Business Interference</b>            | <i>Regulation-based business environment</i>   | <i>Non-business interfering</i>              |
| <b>Internet value for customers</b>     | <i>Right to extract the same value</i>         | <i>Balanced value proposition</i>            |
| <b>Broadband attraction</b>             | <i>Consumers are attracted by new services</i> | <i>Attraction by a personalized offering</i> |

Table 1. List of dimensions in the net neutrality debate

Broadband attraction has been included as a dimension in the net neutrality debate because, in some countries, regulators have been considering the effect of broadband usage on country's competitiveness as one of the pillars in their regulatory efforts. When broadband diffusion reach higher levels of usage network infrastructures could become saturated and country's competitiveness can be stifled. Some voices claim that this circumstance can make worst the take-up of broadband in some countries (MIT, 2005). In this situation, network operators can be forced to invest in increasing network capacity but, at the same time, they could doubt about foreseen investment returns if they could not rely on the neutrality regulation that governments could promulgate.

### 2.3.2 Broadband development vs net neutrality in each country

The most important debate about net neutrality has occurred in North America. The rest of the countries maintain a wait-and-see position. Most of them do not need to take a specific position about net neutrality because, among other things, there is no need to make changes

in the country's broadband communications ecosystem. In the US, one of the most important initiatory facts of the debate was the need to face the renewal of the network infrastructures to manage the new bandwidth-intensive applications that end-users are demanding and content providers are including in their offerings. On the one hand, network operators were not disposed to start the upgrade of their networks without a clear business case. On the other hand, some regional and metropolitan authorities were deploying new broadband infrastructures to improve the competitiveness of their area.

This work proposes to separate some dimensions of the net neutrality debate and to conduct an analysis from the point of view of the effect of broadband development in each country. In order to frame the research, two main factors have been taken into consideration to govern broadband development. The first one is based on the broadband promotional activity of governmental agencies. Most of the countries in Europe and Asia consider that broadband deployment can help their country competitiveness. In this vein, they are issuing programs to help the deployment of high capacity network infrastructures. This kind of activity has been implemented by some American regional and metropolitan administration. The main goal of these initiatives is to substitute network operators and to incentive broadband usage. The second factor is the situation of the broadband penetration rate in a specific country. As it has been stated, broadband penetration has been considered a dimension in the net neutrality debate. Broadband network saturation can force the renewal of network infrastructures and that can lead regulators to consider their position in the net neutrality debate.

#### 2.4 From broadband development to net neutrality scenarios

In this section, we have been discussing about the difficulties in obtaining a framework for agreement on the net neutrality debate. Some difficulties come from the fact that:

- Network neutrality has not been soundly defined (Peña, 2006, Lehr et al, 2006)
- There is a lack of economic theory to study the network neutrality problem (Kocsis and de Bijl, 2007, van Schewick, 2007))

- Regulators, network operators, network users, broadband applications and services providers, and Internet service providers (ISP) are the main actors with divergent interests

These difficulties drive to a situation where many different positions stand and this makes difficult the debate to progress. Some technical features of the network elements fear net neutrality proponents and they claim for a strong regulation to avoid the potential reduction of consumers and society welfare. Network operators need new business cases to justify new investments to upgrade network infrastructures. In some cases, these new investments are the only solution to increase network capacity and to allocate new bandwidth-intensive applications and services. Network operators want to base their new business proposals in a product differentiation basis. Conversely, product differentiation is the major harm that net neutrality proponents forecast for the broadband Internet.

In any case, the need to regulate some basics forms of anticompetitive conduct has a wide support within the scientific community. In addition to the extreme positions, some researchers are proposing some balanced policies on net neutrality that try to reduce the harm and to choose the best options for a net neutrality regulation. This task is not easy because the net neutrality debate has a multidimensional perspective. Moreover, each dimension can be used to maintain a specific position within the debate. Some authors believe that a net neutrality regulation is not going to be implemented in the short run (Bauer, 2006, Peha, 2006, Lehr et al, 2006).

In this work, we postulate that net neutrality positions are going to be mediated by the level of development of broadband networks in the country. In this vein, we consider that the saturation level of broadband networks and the governmental activities to promote broadband diffusion are going to condition the net neutrality debate in the country. To investigate the relationship between these two factors and the neutrality debate, in the following chapters of this paper we propose to analyze broadband promotion programs and broadband diffusion models using a cluster analysis technique. In both cases, a set of patterns are proposed. These patterns are used to build a set of scenarios that map the net

neutrality debate. These scenarios are built taking into consideration the dimensions affected by the two factors we are analysing. In this case, we consider that these two factors influence two of the above mentioned dimensions: Investment and network upgrading, and broadband attraction.

### **3. Country Clustering of broadband promotion programs**

A set of more than one hundred programs in different countries of developed economies have been collected for a period of two years. Programs have been posted in a website<sup>1</sup> that can be reached at <http://teleco.upf.es/poltel>. 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 (Miralles, 2006): 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. The reader can access the previous work to have a complete understanding of the variables of this analysis (Miralles, 2006).

Furthermore, some independent variables were 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. Technology Achievement Index (TAI) has been defined as a composite measure of technological progress that ranks countries on a comparative global scale (Desai et al., 2002). The index was initially developed for the

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<sup>1</sup> At the time of writing this paper, August 2007, this website is not available in English. More information about these programs can be obtained from the author.

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. This 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).

In our 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 14.0) 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.

In this exploratory analysis, the most significant results show that five clusters of countries can characterize country behaviour on broadband public promotions. The profile of the

broadband public promotion programs that each country has issued and some technological variables explain all the patterns. Although some clusters are consistent, others depend on the variables included in the analysis.

***Cluster 1. Information age services.*** Scandinavian countries (Denmark, Norway and Finland) compose this cluster. 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. From the point of view of the strategy, most of the programs in these countries are devoted to give financial support to broadband diffusion. Financial support can be through subsidies or through low-interest loans. Moreover, object of intervention is the second characteristic of the programs in this cluster. In addition, 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 specific objects. For example, Canada, Ireland and France have had a strong activity in rural operator and in dark fibre infrastructure. Moreover, France, Germany and Japan have many programs in promoting local or regional networks. In addition, 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. Moreover, in Spain and Estonia there are programs to provide Internet broadband connection in primary school centres. Finally, regional governments in the UK have issued programs to subsidize 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 2.

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

*Table 2. Characteristics of each cluster*

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 1 and 5 belong to the second group.

#### **4. Diffusion Models for broadband penetration**

Diffusion models have been used to study the evolution of technology adoption in many research strands (Grubestic, 2006, Teng et al, 2002, Kim and Kim, 2004). In our work, we used diffusion models to represent the evolution of broadband penetration in OECD countries. Broadband penetration rate data have been obtained from the OECD statistics and have been listed in table 6 (see Appendix 1).

The Bass model (Teng et al, 2002) has been used to get the parameters of the broadband diffusion in each country. Bass model belongs to the group of fundamental diffusion models. In these models the rate of diffusion is proportional to the number of potential adopters at a given time  $t$ . The Bass models can be expressed with the following equation:

$$P(t) = m \frac{1 - \exp(-t(a + b))}{1 + \frac{b}{a} \exp(-t(a + b))}$$

where

- $P(t)$  is the number of consumers that have adopted broadband in a specific Country at time  $t$
- $m$  is the number of potential adopters in the social system, also known as the saturation level
- $b$  is the coefficient of diffusion. In the Bass model is also known as the imitation coefficient
- $a$  is the innovation coefficient.

A reduced version of this model is known as the logistic model. The logistic model is obtained when the innovation coefficient is zero ( $a = 0$ ). In our work, we have used the Bass model when the logistic model was not appropriate enough in terms of quadratic error. In Table 7 all countries that have analyzed using the logistic model have a 0 on the “Inn.Coeff” column.

Bass model and logistic model have been used to calculate the broadband diffusion behaviour for each country. Results can be seen in table 7. For each country, this table shows: the saturation level, the diffusion coefficient ( $b$ ), the coefficient of innovation ( $a$ )

and the quadratic error that was obtained with the model. In addition to the Bass model, each country was characterized by the number of years that the country spent to reach a penetration rate of 2%. This parameter has been used to characterize the time to reach the critical mass (Kim and Kim, 2004). When a technology reach the critical mass starts a positive evolution in their diffusion process.

Following the strategy of other previous researchers, a cluster analysis has been performed in order to classify all countries based on their diffusion process. The classifying variables were the number of years to reach the critical mass, the saturation level, and the diffusion coefficient. A hierarchical approach was used and results are shown in table 8. Seven clusters were obtained that include those countries with similar diffusion behaviour. Characteristics of each country have been included in the following table (Table 3):

| Cluster and Countries  | Characteristics              |   |                              |
|--|------------------------------|---|------------------------------|
|  | "Critical mass" reach year   | Average diffusion coefficient growth rate | Penetration rate             |
| 0. Canada and Korea  | Early 2000                   | Very low                                  | High                         |
| 1. Austria, Belgium, Sweden and United States  | From late 2000 to early 2001 | Low                                       | Between medium-high and high |
| 2. Denmark, Germany and Iceland  | Mid 2001                     | Medium-low                                | Between medium-high and High |
| 3. Czech Republic, Greece, Ireland, Mexico, Slovak Republic, and Turkey                | From mid 2004 to early 2006  | Very high                                 | From low to medium           |
| 4. Hungary, New Zealand, and Poland  | From mid 2003 to late 2004   | Medium-high                               | From low to medium           |
| 5. Australia, Italy, Luxembourg, and Portugal  | From mid 2002 to early 2003  | High                                      | Between medium-high to high  |
| 6. Finland, France, Japan, Netherlands, Norway, Spain, Switzerland, and United Kingdom | From early 2001 to late 2002 | Medium-high                               | From medium to high          |

*Table 3. Characteristics of clusters obtained in the analysis of broadband diffusion in each country*

The diffusion coefficient shows the broadband penetration rate growth in the last years. Countries in clusters 0, 1, and 2 have a high penetration rate but in the last years, they have reduced their rate growth compared to the growth of previous years. Conversely, countries in cluster 6 have maintained their growth rate.

## 5. Scenarios for network neutrality practices

Following the analysis performed in previous sections, the main outcome is that countries in this work form to big groups. On the one hand, those countries with high penetration rate form a group of countries with a specific behaviour (clusters 0, 1 2, and 6 build this group). On the other hand, countries with high diffusion coefficient form another group. All the countries in the high penetration rate group started their broadband deployment early. All of them reached the critical mass before ending year 2000. Another characteristic of this group is that the diffusion coefficient for clusters 0, 1, and 2 is very low. For cluster 6, its value is in the mid-range of those we have analyzed. Based on their broadband promotion behaviour, these countries have issued programs to promote infrastructures and to promote services. The most important aspect to highlight is that programs to promote local, metropolitan and rural networks have not been obtained in countries with a medium diffusion coefficient. See table 4 for a summary of this group of countries.

| High penetration rate  | Diffusion Coefficient                  |        |
|------------------------|--|--------|
| Governmental promotion | Low                                    | Medium |
| Infrastructures        | Broadband networks                     |        |
|                        | Local, metropolitan and rural networks |        |
| Services               | Information age services               |        |
|                        | Support to specific groups of users    |        |

Table 4. Summary of the promotional activity in high penetration rate countries

All countries in the high diffusion coefficient group have experienced a high growth rate of broadband in the last years (see Table 5 for a summary). We find two subgroups of countries within this group. First, there is a subgroup with a low penetration rate. Most of these countries reached broadband critical mass in 2005 and they have had big growth rates in the last years. Promotional activity has focused on issuing programs to promote infrastructures, mainly broadband networks. Secondly, the other subgroup is characterized by a medium penetration rate. Services are the main object of these countries' promotional activity.

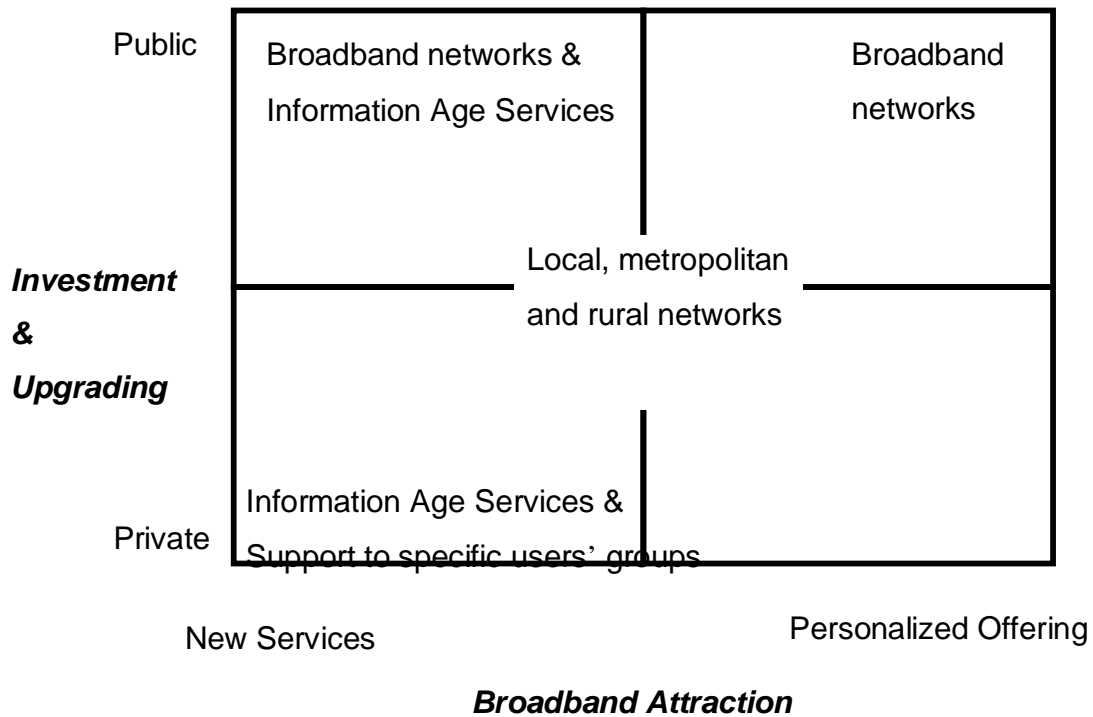
| High Diffusion Coefficient | Penetration rate   |                                     |
|----------------------------|--------------------|-------------------------------------|
|                            | Low                | Medium                              |
| Governmental promotion     |                    |                                     |
| Infrastructures            | Broadband networks |                                     |
| Services                   |                    | Support to specific groups of users |

*Table 5. Summary of the promotional activity in high diffusion coefficient countries*

These two groups of countries allow proposing a set of scenarios based on the two dimensions of the net neutrality debate that are relevant to our work. In figure 1 and figure 2 we propose the set of scenarios that can be obtained from this work analysis. Figure 1 shows the different scenarios for the high penetration rate case. These scenarios are obtained using the two dimensions: Investment and Upgrading Network, and Broadband attraction. These scenarios are:

- Broadband networks and information age services: In this scenario, we include countries that have developed broadband network deployment and at the same time have issued programs to support the launch of information age services.
- Broadband networks: This scenario includes those countries with a focus on deploying broadband networks.
- Local, metropolitan and rural networks: This scenario includes those countries that have only deployed networks in areas where main operators are not interested.

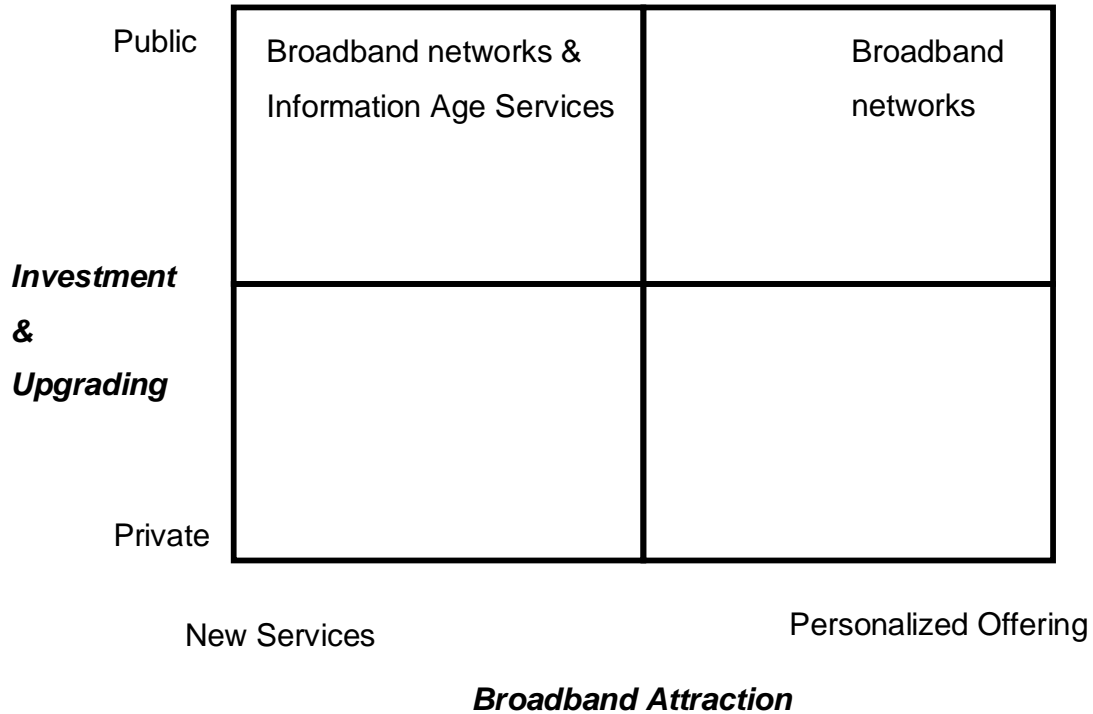
## ***High Penetration Rate***



- Information age services and support for specific users' groups: Countries within this scenario have not been interested in building new broadband networks.

In figure 2, two scenarios have been proposed for high diffusion coefficient countries. Both scenarios include deploying new broadband networks. The first one, in addition to deploying new networks, includes the provision of information age services.

## ***High Diffusion Coefficient***



### **6. Conclusions, limitations and future research**

This work proposes a multidimensional view of the net neutrality debate. Based on this perspective, we propose to study how broadband diffusion is going to effect the net neutrality regulation in some countries. Two factors are analyzed in order to study the effect of broadband development in the net neutrality debate. In most of the countries, governmental agencies are promoting broadband deployment by issuing broadband promotion programs. Hence, governmental role in broadband development is the first factor that is analyzed in this study. The second factor that completes this analysis is the profile of each country in the broadband penetration rate. A diffusion model has represented each country's profile. These two factors are used to describe a set of scenarios related to the dimensions of the net neutrality debate.

This work presents a set of limitations. The first one is that, unfortunately, not all countries that have been used to analyse the governmental promotion behaviour have been included in the analysis of the second factor. This limitation comes from the fact that only a limited number of countries were included in the collection of the broadband promotion programs analysis. In addition, this study has been limited to a first approach for the proposal of scenarios.

Future research will be focused, firstly, on trying to complete the information about promotion programs for those countries that have not been included in the current analysis. Secondly, the set of scenarios need to be compared with the actual trends in the regulation of each country.

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## Appendix 1. Data Tables

| COUNTRY         | y1999       | y2000       | y2001      | y2002      | y2003      | y2004       | y2005       | y2006       |
|-----------------|-------------|-------------|------------|------------|------------|-------------|-------------|-------------|
| Australia       | 0,07        | 0,39        | 0,9        | 1,8        | 3,5        | 7,7         | 13,8        | 19,2        |
| Austria         | 0,63        | 1,7         | 3,6        | 5,6        | 7,6        | 10,1        | 14,3        | 17,3        |
| Belgium         | 0,5         | 1,42        | 4,4        | 8,7        | 11,7       | 15,5        | 18,2        | 22,5        |
| Canada          | 1,9         | 4,54        | 8,9        | 12,1       | 15,1       | 17,6        | 21          | 23,8        |
| Czech Republic  | 0           | 0,1         | 0,1        | 0,2        | 0,5        | 2,5         | 6,4         | 10,6        |
| Denmark         | 0,22        | 1,27        | 4,4        | 8,2        | 13         | 19          | 24,9        | 31,9        |
| Finland         | 0,15        | 0,58        | 1,3        | 5,5        | 9,5        | 14,9        | 22,4        | 27,2        |
| France          | 0,08        | 0,31        | 1          | 2,8        | 5,9        | 10,5        | 15,1        | 20,3        |
| Germany         | 0,006       | 0,32        | 2,3        | 4,1        | 5,6        | 8,4         | 13          | 17,1        |
| Greece          | 0           | 0           | 0          | 0          | 0,1        | 0,4         | 1,4         | 4,6         |
| Hungary         | 0           | 0,03        | 0,3        | 0,6        | 2          | 3,6         | 6,3         | 11,9        |
| Iceland         | 0           | 0,7         | 3,7        | 8,4        | 14,3       | 18,2        | 26,4        | 29,7        |
| Ireland         | 0           | 0,01        | 0,1        | 0,3        | 0,8        | 3,3         | 6,7         | 12,5        |
| Italy           | 0,002       | 0,2         | 0,7        | 1,7        | 4,1        | 8,1         | 11,8        | 14,8        |
| Japan           | 0,12        | 0,5         | 2,2        | 6,1        | 10,7       | 15          | 17,6        | 20,2        |
| Korea           | 0,6         | 9,2         | 17,2       | 21,8       | 24,2       | 24,8        | 25,2        | 29,1        |
| Luxembourg      | 0           | 0           | 0,3        | 1,5        | 3,5        | 9,8         | 14,9        | 20,4        |
| Mexico          | 0           | 0,02        | 0,1        | 0,3        | 0,4        | 0,9         | 2,2         | 3,5         |
| Netherlands     | 0,95        | 1,68        | 3,8        | 7          | 11,8       | 19          | 25,2        | 31,8        |
| New Zealand     | 0           | 0,27        | 0,7        | 1,6        | 2,6        | 4,7         | 8,1         | 14          |
| Norway          | 0,09        | 0,34        | 1,9        | 4,2        | 8          | 14,8        | 21,8        | 27,5        |
| Poland          | 0           | 0           | 0,1        | 0,3        | 0,8        | 2,1         | 2,4         | 6,9         |
| Portugal        | 0           | 0,26        | 1          | 2,5        | 4,8        | 8,2         | 11,5        | 13,8        |
| Slovak Republic | 0           | 0           | 0          | 0          | 0,3        | 1           | 2,5         | 5,7         |
| Spain           | 0,004       | 0,15        | 1,2        | 3          | 5,4        | 8,1         | 11,5        | 15,3        |
| Sweden          | 0,12        | 1,86        | 5,4        | 8,1        | 10,7       | 14,5        | 20,2        | 26          |
| Switzerland     | 0,001       | 0,43        | 2          | 5,6        | 10,1       | 17,5        | 24,1        | 28,5        |
| Turkey          | 0           | 0           | 0          | 0          | 0,3        | 0,7         | 2,1         | 3,8         |
| United Kingdom  | 0           | 0,09        | 0,6        | 2,3        | 5,4        | 10,5        | 16,4        | 21,6        |
| United States   | 0,65        | 2,25        | 4,5        | 6,9        | 9,7        | 12,9        | 16,3        | 19,6        |
| <b>OECD</b>     | <b>0,28</b> | <b>1,27</b> | <b>2,9</b> | <b>4,9</b> | <b>7,3</b> | <b>10,2</b> | <b>13,5</b> | <b>16,9</b> |
| <b>EU15</b>     | <b>0,1</b>  | <b>0,39</b> | <b>1,6</b> | <b>3,4</b> | <b>5,9</b> | <b>9,7</b>  | <b>14,2</b> | <b>18,6</b> |

Table 6. Broadband Penetration in home percentage (Source : OECD)

| Country         | Saturation | Diff.Coeff. | Inn.Coeff. | Error (*10 <sup>-3</sup> ) |
|-----------------|------------|-------------|------------|----------------------------|
| Australia       | 0,245      | 1,02        | 0          | 0,035262                   |
| Austria         | 0,84       | 0,25        | 0,013      | 0,046                      |
| Belgium         | 0,71       | 0,175       | 0,029      | 0,354                      |
| Canada          | 0,511      | 0,061       | 0,066      | 0,091                      |
| Czech Republic  | 0,131      | 1,441       | 0,001      | 0,0067064                  |
| Denmark         | 0,56       | 0,425       | 0,026      | 0,077                      |
| Finland         | 0,338      | 0,775       | 0,013      | 0,183                      |
| France          | 0,275      | 0,755       | 0,01       | 0,0381                     |
| Germany         | 0,64       | 0,36        | 0,011      | 0,0983                     |
| Greece          | 0,225      | 1,351       | 0          | 0,0000368                  |
| Hungary         | 0,451      | 0,681       | 0,004      | 0,029048                   |
| Iceland         | 0,401      | 0,446       | 0,067      | 0,38137                    |
| Ireland         | 0,161      | 1,431       | 0          | 0,075747                   |
| Italy           | 0,17       | 0,991       | 0,006      | 0,00718                    |
| Japan           | 0,21       | 0,885       | 0,024      | 0,0933                     |
| Korea           | 0,191      | 0,001       | 0,505      | 0,67754                    |
| Luxembourg      | 0,241      | 1,006       | 0,028      | 0,1107                     |
| Mexico          | 0,055      | 1,031       | 0          | 0,0041214                  |
| Netherlands     | 0,406      | 0,713       | 0          | 0,0632                     |
| New Zealand     | 0,355      | 0,739       | 0          | 0,038649                   |
| Norway          | 0,35       | 0,805       | 0,01       | 0,0257                     |
| Poland          | 0,541      | 0,806       | 0,002      | 0,11103                    |
| Portugal        | 0,148      | 1,073       | 0          | 0,054464                   |
| Slovak Republic | 0,134      | 1,158       | 0          | 0,00086251                 |
| Spain           | 0,24       | 0,57        | 0,017      | 0,0337                     |
| Sweden          | 0,88       | 0,24        | 0,02       | 0,214                      |
| Switzerland     | 0,33       | 0,85        | 0,13       | 0,0391                     |
| Turkey          | 0,065      | 1,125       | 0          | 0,0023547                  |
| United Kingdom  | 0,271      | 0,876       | 0,016      | 0,0051285                  |
| United States   | 0,39       | 0,265       | 0,039      | 0,0022                     |
| <b>OECD</b>     | 0,21       | 0,505       | 0,036      | 0,014                      |
| <b>EU15</b>     | 0,28       | 0,63        | 0,014      | 0,00782                    |

*Table 7. Parameters of the Bass Model for each country*

| Country         | Cluster | Critical Mass | Saturation | Diff.Coeff. |
|-----------------|---------|---------------|------------|-------------|
| Canada          | 0       | 0,04          | 0,511      | 0,061       |
| Korea           | 0       | 0,16          | 0,191      | 0,001       |
| Austria         | 1       | 1,16          | 0,84       | 0,25        |
| Belgium         | 1       | 1,19          | 0,71       | 0,175       |
| Sweden          | 1       | 1,04          | 0,88       | 0,24        |
| United States   | 1       | 0,84          | 0,39       | 0,265       |
| Denmark         | 2       | 1,23          | 0,56       | 0,425       |
| Germany         | 2       | 1,85          | 0,64       | 0,36        |
| Iceland         | 2       | 1,43          | 0,401      | 0,446       |
| Czech Republic  | 3       | 4,75          | 0,131      | 1,441       |
| Greece          | 3       | 6,19          | 0,225      | 1,351       |
| Ireland         | 3       | 4,48          | 0,161      | 1,431       |
| Mexico          | 3       | 5,85          | 0,055      | 1,031       |
| Slovak Republic | 3       | 5,67          | 0,134      | 1,158       |
| Turkey          | 3       | 5,93          | 0,065      | 1,125       |
| Hungary         | 4       | 4,00          | 0,451      | 0,681       |
| New Zealand     | 4       | 3,40          | 0,355      | 0,739       |
| Poland          | 4       | 4,92          | 0,541      | 0,806       |
| Australia       | 5       | 3,12          | 0,245      | 1,02        |
| Italy           | 5       | 3,13          | 0,17       | 0,991       |
| Luxembourg      | 5       | 3,25          | 0,241      | 1,006       |
| Portugal        | 5       | 2,67          | 0,148      | 1,073       |
| Finland         | 6       | 2,17          | 0,338      | 0,775       |
| France          | 6       | 2,56          | 0,275      | 0,755       |
| Japan           | 6       | 1,88          | 0,21       | 0,885       |
| Netherlands     | 6       | 1,15          | 0,406      | 0,713       |
| Norway          | 6       | 2,04          | 0,35       | 0,805       |
| Spain           | 6       | 2,44          | 0,24       | 0,57        |
| Switzerland     | 6       | 2,00          | 0,33       | 0,85        |
| United Kingdom  | 6       | 2,82          | 0,271      | 0,876       |

*Table 8. Clustering variables for each country*