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The Nature, Timing and Impact of Broadband Policies: a Panel Analysis of 30 OECD Countries

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Abstract - We empirically investigate the impact of a vast array of public policies on wireline broadband penetration through a novel and unique dataset covering 30 OECD countries, over 1995-2010. We find that while both supply and demand-side policies have a positive effect on broadband penetration, their relative impact depends on the actual stage of broadband diffusion. When an advanced stage is reached, only demand-side policies appear to generate a positive and increasing effect. Moreover, both technological and market competition play a positive role, and the effect of the latter shows a non-linear path along the stage of market development. Finally, the relative weight of the service sector in the national economy reveals to be crucial for broadband penetration. Our analysis provides new insights into the policy debate and in particular on the rationale of a selective policy design for broadband penetration and, in perspective, for the rollout of next-generation networks.

Keywords: *telecommunications policies, broadband penetration, infrastructure investments*

JEL Classification: K200, L960, O310, O570

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1. Introduction

Broadband infrastructures are increasingly perceived as a key factor influencing the competitiveness and the growth potential of nations, facilitating job creation. In Germany, for instance, it has been estimated (CBS, 2010) that an investment of 36 billion euros will return about 22 billion euros to the economy during network construction, as well as positive externalities for the whole economy equal to 137 billion. In China, the development of dial-up and broadband Internet may contribute an extra 2.5 per cent increase in the growth of gross domestic product, for each 10% raise in penetration (VP, 2009). Other studies suggest that, for low- and middle-income countries, a 10-per cent rise in broadband penetration could add up to a 1.4-per cent point rise in economic growth (BCDD, 2011, pp. 6-7). According to these predictions, countries urge to implement national broadband plans or risk losing the benefits of the global high-speed digital communications.

In view of the perceived salience, also within public opinion, of the issue of broadband deployment, most governments around the world have adopted policy interventions aimed at promoting investment. Almost all OECD countries have enacted more or less intense policy measures, often in the form of integrated plans requiring the coordination of action at various government levels, with some countries such as South Korea, Japan, the Netherlands, UK and, more recently, Australia, showing particularly high degrees of activism.

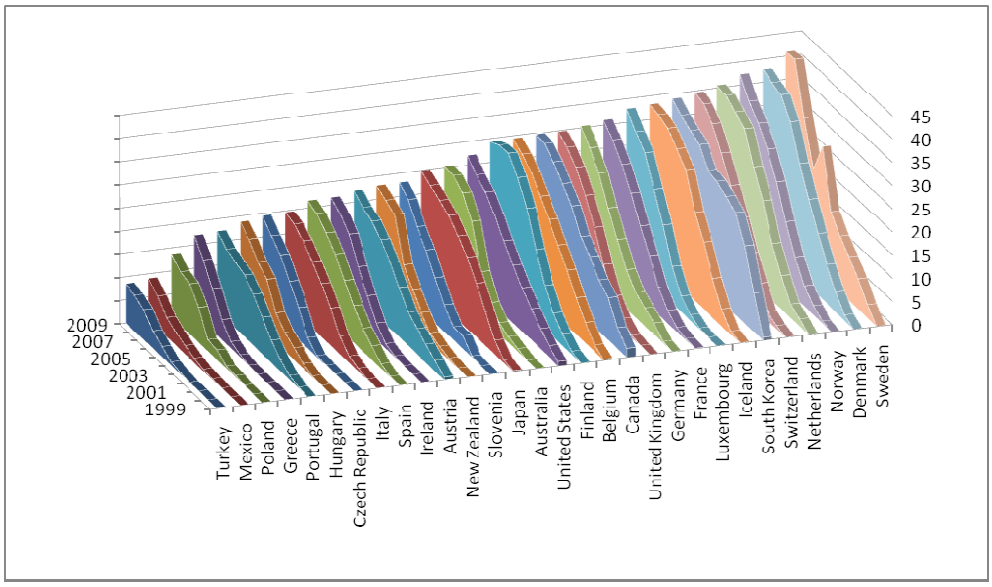
The relevance of broadband diffusion for economic activity relates to the range of new and/or better applications that it enables. These include not only enhanced communication services and video streaming, but also new services in the domain of e-commerce, e-health, e-government and e-education, just to mention the most prominent examples. In addition to this, broadband is widely believed to be a factor stimulating productivity growth, with positive consequences in terms of economic development, and to have positive effects in terms of social cohesion.

In spite of the relatively uncontroversial recognition of the benefits of the existence of efficient broadband infrastructures, the nature and extent of public policy intervention is still the object of many economic, political and regulatory debates. Three main objectives of broadband public policy could be outlined (BCDD, 2011): extending the geographic coverage of broadband to areas currently not covered because of high costs of doing so (i.e. reducing or eliminating the so-called *digital divide*); promoting broadband adoption by the largest possible number of citizens; and improving the technological performance of existing networks by introducing ultra-broadband infrastructures.

In the past few years, different governments have not only chosen different combinations of the above objectives, but they have also adopted a particularly wide range of forms of intervention to stimulate investment in wireline broadband deployment (supply-sided and

demand-sided) which also explains the significant variance in wireline broadband uptake observed in a sample of 30 OECD countries (Fig. 1).

Figure 1. Wireline broadband diffusion in OECD countries (number of subscribers per 100 inh.).



Source: authors' elaboration on ITU's (2010) data.

Surprisingly, while the debate on the appropriate role of governments with respect to broadband investment has been intense, the research on the complementarity or substitutability degree between public and private policies on the one hand, as well as between supply-side and demand-side on the other, is still in its infancy (Cava-Ferreruela and Alabau-Munoz, 2006; Jeanjean, 2010).

In this paper, extending on our previous cross-sectional analysis (Belloc, Nicita and Rossi, 2009) we attempt to fill this gap, by empirically investigating wireline broadband policies in 30 OECD countries, through a novel and unique dataset (*International Broadband Policies Database* (IBPD), Rossi, 2010)), over twenty five years (1995-2010). We disentangle several supply-sided and demand-sided policies adopted in 30 OECD countries, and measure their relative impact on wireline broadband promotion, taking into account the stage of development of the country's broadband infrastructures, as well as the degree of technological and market competition.

Four main conclusions can be drawn from our empirical analysis.

First, public policy involvement is worthwhile, providing a clear and significant stimulus to broadband penetration. Second, in choosing among the available policy tools, governments should not disregard demand-side interventions. Indeed, while demand-side policies tend to be less prominent in the policy debate, they reveal nonetheless greater impact on broadband penetration in light of our analysis. Third, governments interested in enhancing wireline broadband penetration should devise articulated strategies and avoid the adoption of piecemeal

interventions. Our findings show that demand-side and supply-side policies are complementary in this respect, being more effective if jointly undertaken. Finally, we find that, in addition to policies purposefully devised to stimulate broadband investment, a particularly relevant role should be attributed to the wider institutional environment the countires face when enacting their policies, as our analysis reveal that institutional characteristics play the role of "enabling" factors. In particular, we find that while both supply and demand-side policies have a positive effect on broadband diffusion at a lower stage of broadband penetration, when an advanced stage is reached, only demand-side policies appear to generate a positive and increasing effect. Moreover, both technological and market competition play a positive role, and the effect of the latter shows a non-linear path along the stage of market development, as public policies exert different effects on broadband adoption at different levels of the telecommunications market development. Finally, the relative weight of the service sector in the national economy reveals to be crucial for broadband adoption, showing a greater impact as the dimension of the service sector increases.

To our knowledge, there is currently no study, besides the present one, that explicitly addresses the issue of the impact of alternative forms of public policy intervention on broadband penetration, while acknowledging the role played by 'institutional' initial conditions in affecting the policies' performance. Our results may shed new lights on the policy debate, in particular over the definition of the most appropriate, country-specific policy design to be adopted for broadband promotion and, in perspective, for the rollout of next-generation networks.

The paper is structured as follows. Section 2 briefly reviews the existing empirical literature that, although focusing more generally on the determinants of broadband penetration, is broadly related to the present paper. In Section 3, an overview of the main public policy tools for the promotion of broadband investment is provided. Section 4 illustrates the data used in this study and describes the variables. Section 5 contains our econometric analysis and outlines our findings. Section 6 concludes.

2. Previous empirical literature on broadband penetration policies

While a precise definition of wireline broadband is difficult to find due to the rapid evolution of technology and the existence of a range of alternative interpretations by different institutions, an acceptable way to define wireline broadband is by reference to what broadband connectivity is not, namely a dial-up service for access to the Internet, and to what broadband is for sure, namely a way for consumers to enjoy high speed, two-way and always-on connectivity to the Internet. In other words, the availability of a broadband infrastructure implies the possibility to connect to the Internet at a faster speed than conventional dial-up services. About how much faster such

connection should be to qualify, as broadband there is, however, no agreement. The International Telecommunications Union, for instance, defines as broadband Internet connectivity faster than that affordable with primary rate ISDN, i.e. 1,5 or 2 Mbps (see the Recommendation I.113 of the ITU Standardization Sector - ITU-T). The Organization for Economic Cooperation and Development, by contrast, in various official documents has made reference to the lower threshold of a download speed of 256 Kbps (OECD, 2001).

Irrespective of the precise definition, wireline broadband services may be delivered through various different technologies[1], whose diffusion has been the focus of a growing body of empirical research. In particular, three broad categories of studies addressing the issue of broadband deployment can be singled out:

(a) studies that investigate the determinants of broadband demand;

(b) studies that consider both supply and demand factors by examining the link between population characteristics, infrastructure investments and broadband access;

(c) studies that examine the link between regulatory policy choices and broadband investment and/or uptake.

The first category of studies (a), generally uses micro-data, where the statistical unit is the household and the dependent variable is a binary choice (i.e. the use of a broadband/dial-up Internet connection). Trying to address the determinants of demand, this first body of research focuses on household characteristics (such as household size, income, age and education) while, on the supply side, only the price of broadband and dial-up service is included. For example, in the study by Rappaport *et al.* (2003), multinomial logistic models are implemented on a sample of about 20.000 US households and it is found that education and income level positively affect broadband use in individual households. Probabilistic models have been also used to examine individual households' decisions, and broadband adoption by Madden and Simpson (1997) and Madden *et al.* (1999) for Australia, Takanori and Toshifumi (2006) for Japan, Cerno and Pérez-Amaral (2007) for Spain, and Cardona *et al.* (2009) for Austria.

The second category of studies (b), focuses on the geographical digital divide and on the reasons of spatial disparities rather than on the choice of individual households and considers demand characteristics as a determinant of telecommunication firms' investments in specific

[1] The most widespread technology is, so far, the *Digital Subscriber Line* (DSL) technology, which relies on the existing telecommunication copper network to provide connection speeds ranging from 256 Kbps to 52 Mbps, depending on the specific type of DSL (Asymmetric DSL (ADSL), High Rate DSL (HDSL), Symmetric DSL (SDSL) and Very High Data Rate DSL (VDSL)). The second most widespread technology is the *Cable Modem*, which provides faster connection speeds than the DSL (in the range of 1 to 10 Mbps), allowing for the simultaneous passage on the TV cable of triple-play services: voice, data and television. Other relevant technologies for the provision of wireline broadband services include *Power Line Communications* (PLC, based on the electricity transmission network), and, most importantly in terms of quality and potential, *Optic Fibre*. Deployment of the latter allows the building of an Internet Protocol-based network that is normally referred to as *Next Generation Network*.

areas. Grubesic (2003) explores broadband access options in the state of Ohio (in the USA) and finds that income, education, age, location and competition from alternative broadband platforms influence DSL infrastructure investment leading to a urban/rural divide. Similarly, Bauer *et al.* (2003), implementing a supply-demand model on a sample of 30 OECD countries, show that the potential demand (along with cost conditions of deploying advanced networks) is one of the most influential factors explaining broadband uptake, although the relative income position appears not significant in their estimation.

In a more recent paper, Cava-Ferreruela and Alabau-Munoz (2006) implement a supply-demand model similar to that of Bauer *et al.* (2003) and provide more robust results. The two authors examine a sample of 30 OECD countries from 2000 to 2002 and explore the factors influencing broadband demand, supply and adoption. By performing multivariate regression analysis, Cava-Ferreruela and Alabau-Munoz (2006) find that technological competition and the low cost of deploying telecommunication infrastructures are likely to be the key drivers for broadband supply, while the predisposition to use new technologies is the crucial determinant of broadband demand. In particular, they show a positive correlation between broadband penetration, on the one hand, and income, household density, population density, urban population, education and competition between technologies, on the other. By contrast, market competition (measured by the percentage of telephone lines of new entrants) does not seem to have a significant influence on the availability of broadband infrastructures for DSL or for cable technology. Nevertheless, other studies (see, e.g., Garcia-Murillo and Gabel, 2003) report a positive and statistically significant effect of market competition on the percentage of broadband users in a given country. Finally, that private and business demand drives broadband investments and penetration, is also found by Prieger (2003) on US data. Prieger extends his analysis to some proxies for the composition of the business market (considering the percentage of manufacturing and services firms and firms' dimension) that, however, do not show statistically significant effects.

As for the third category of studies (c), it includes investigations of the link between price regulation and investment (see, e.g., Greenstein et al., 1995; Ai and Sappington, 2002), showing that incentive regulation regimes have a better performance with respect to RoR regulation in terms of investment incentives. It also includes analyses of the link between access regulation and investment, and particularly of the effect of local loop unbundling on investment. The empirical evidence is not univocal on this issue. Indeed, some studies find that mandatory unbundling has a negative effect on investment (see, e.g., Crandall et al., 2004; Wallsten and Hausladen, 2009), while others find evidence supporting the existence of non-negative effects on investment (see, e.g., Ford and Spiwak, 2004; Fevrier and Saer, 2007; Distaso et al., 2005).

As mentioned above, despite the rich array of results provided by these empirical studies, a systematic analysis of the role played by policy interventions, different from regulatory choices, is still missing. This might be due, on the one hand, to the limited availability of data, that strongly constrains empirical models on this issue (especially when one tries to introduce policy variables), and forces researchers to caution in interpreting estimation results. On the other hand, it may derive from the fact that the few available results do not appear to be particularly encouraging. Bauer et al. (2003), for example, add to their econometric model some dummies reflecting policy regimes (that include unbundling, the separation of cable and telephone company ownership, and the availability of government funding to support broadband deployment), which, however, do not produce statistically significant parameter estimates. Similarly, a comparative study of broadband diffusion in Asia by Aizu (2002), reports that government policies do not have much influence in promoting broadband use. Nevertheless, tax incentives to encourage firms to serve underserved markets are suggested by some authors (see, for instance, Gabel and Kwan, 2002) along with "medium-intervention strategies" involving both supply-side actions to assist in the establishment of broadband networks and demand-side actions to promote broadband service adoption (Cava-Ferreruela and Alabau-Munoz, 2006).

Building on these previous empirical studies we attempt, in the following sections, to overcome the above difficulties and to investigate some issues left unexplored by the previous research. We perform a new empirical analysis of the impact of alternative public policies on wireline broadband promotion, based on a unique and original database, covering the vst array of policy options adopted in 30 OECD countries from 1995 to 2010.

3. Identifying a comprehensive set of broadband policy tools

Before starting our econometric analysis, we need to identify and disentangle the many broadband policy tools, which might be adopted in each country at different levels of government. The range of policy instruments available to public decision-makers, to stimulate wireline broadband penetration, includes at least three sets of tools.

The first concerns directly the domain of telecommunications regulation and is made up of the various regulatory interventions that may contribute to create an investment-friendly regulatory environment. Among these, at least three sorts of measures have attracted considerable attention: (a) regulatory measures aimed at directly modifying the degree of vertical integration of the existing telecommunications network by introducing operational, functional or structural separation of the incumbent's network; (b) access regulation; and (c) incentive regulation. There is

a vast, albeit not conclusive, theoretical and empirical literature on these topics, particularly on the effects of access and incentive regulation on broadband investment (for a comprehensive survey, see Cambini and Jiang, 2009).

The second set of tools includes a varied ensemble of supply-side policy measures that may lower the cost of private investment, integrate it or substitute for it in scarcely attractive areas. The third includes demand-side policy measures aimed at increasing the revenue side of broadband investment projects either by stimulating business and/or consumer demand or by expressing additional public demand. The latter two sets of policy tools can be categorized as "industrial policies" (Figure 2), as opposed to regulatory measures[2].

Figure 2.

SUPPLY-SIDE POLICIES	DEMAND-SIDE POLICIES
· adoption of fiscal incentives programs and subsidies	· initiatives of public demand of specific services
· implementation of long-term loans programs for broadband suppliers and national financing programs	· provision of incentives to business demand
· creation of Public-Private Partnerships with public ownership of the infrastructure network	· provision of incentives to private demand
· creation of Public-Private Partnerships with private ownership of the infrastructure network	· provision of demand subsidies in favor of individual consumers or particular categories of consumers
· implementation of territorial mapping programs	· adoption of demand aggregation policies
· initiatives of administrative simplification	

In the rest of this section, the main forms of industrial policy intervention will be briefly reviewed, so as to better introduce the policies that will be taken into account in the empirical analysis. Regulatory measures are outside the scope of the empirical assessment and will therefore not be reviewed.

3.1 Supply-side policies

Supply-side industrial policies include a varied range of policy tools that express different levels of financial commitment by public decision-makers and have been adopted in various different

[2] There are a number of categorizations of the forms of policy interventions available to governments for the promotion of broadband penetration different from the one we adopt in this paper. Gillett et al. (2004), for instance, propose a taxonomy of forms of intervention based on the role played by the state, distinguishing among contexts whereby the state operates as a (1) broadband user; (2) rule-maker; (3) financier; or (4) infrastructure developer. Falch (2007) introduces a distinction among (1) direct intervention; (2) regulation; and (3) facilitation. Other categorizations are also possible. We adopt the distinction between supply-side and demand-side policies because it is the most common in public policy analysis and because it appears to be particularly salient in the current debate.

combinations by OECD countries. In what follows, each of the most common forms of supply-side policies will be briefly described.

Fiscal incentives programs and subsidies.

Under this label can be listed the fiscal measures aimed at stimulating broadband supply, such as tax credits (adopted particularly in the US) and subsidies to broadband providers (such as, for instance, in Canada).

Long-term loans programs for broadband suppliers and national financing programs.

Korea and Japan have historically been the countries most prone to finance initiatives for improving broadband penetration (among the most relevant programs in this regard are the "*KII-initiative*", the "*IT839 Strategy*" and the "*Broadband Korea vision 2007*" for Korea and "*U-Japan*" and "*The Next Generation Broadband Strategy 2010*" for Japan). More recently, almost all of the other OECD countries have followed suit, either through central government guarantees and/or long-term loans to TLC operators (this has occurred, among other countries, in the US, with the plans "*Rural Broadband Access Loan*" and "*Guarantees Program*", and in Spain, with the plans "*Avanza Plan*" and "*Ingenio 2010*"), or through the financing of local administrations involved in the creation of new infrastructures or in the improvement of existing ones, often with the aim of filling the technological gap of rural areas (this has occurred particularly in Norway, with the plan "*Broadband for all*", in Greece, where the State has financed the realization of a new backbone network and, more generally, in a number of EU countries where EU structural funds are used to finance the development of underdeveloped areas).

Public-Private Partnerships.

Public funds may also be involved in the creation of *Public-Private Partnerships* (hereinafter, PPPs), although they do not constitute an essential element of these agreements. Recourse to PPPs is, indeed, often motivated by the public sector's objective to attract private capital towards infrastructure financing, so as to complement or substitute for limited public resources. PPPs may take many different forms, associated to different degrees of involvement of public players. In some cases, often denominated *Private Finance Initiatives* or DBFO (*Design-Build-Finance-Operate*), financial resources are predominantly of a private nature. In other cases, the presence of public capitals is more substantial. This is the case for PPPs in the form of DBO (*Design-Build-Operate*), BOT (*Build-Operate and Transfer*), BT (*Build and Transfer*), BRT (*Build-Rent and*

Transfer). In the latter cases the infrastructure is typically owned by the public sector and maintained and operated by the private sector on an open access basis.

Relevant examples of the adoption of PPPs include the experience of *CityNet* in Amsterdam, the experience of "*FibreSpeed*" and "*Connected Community*" in the UK, a range of cases in France, where a specific legal framework has been set in place and, more recently, the cases of New Zealand and Australia, where the government has adopted plans to institute PPPs for the deployment of fibre networks of an FTTH type (Fibre-to-the-Home), with a substantial input of public funds. In particular, the Australian *National Broadband Network* of April 2009 envisaged an investment of 23.6 billion euros in order to cover 90% of the population through an NGN that operates only at the wholesale level. In New Zealand, the government has proposed in 2009 to finance up to 50% of the costs of a new broadband access network that would cover 75% of the population.

Territorial mapping programs.

These are public initiatives aimed at supporting investment decisions by private operators by providing detailed information on the existing broadband coverage and eventually on the potential demand expressed in different geographic locations of the country. Notable initiatives in this regard include those undertaken in Norway, in Sweden, where the *Swedish IT Policy Group* has promoted the implementation of a public register of excavations made by local administrations, and in Korea, where since 1997 a system of certification has been put in place that assigns a higher score to buildings connected through optic fibre ("*Cyber Building Certificate*") so as to transmit information to telecom operators and, at the same time, provide incentives to real estate developers to coordinate with telcos to include fiber optic connections in new buildings.

Administrative simplification.

A number of OECD countries has adopted initiatives aimed at reducing the bureaucratic costs involved by broadband investments, such as those relating to excavation permits, rights of way and various other sorts of licenses. Examples of adoption of this sort of policies date back to the beginning of the 1990s and include the 1991 Belgian law on road public works, the 1993 Canadian Telecommunications Act, that includes special provisions for civil infrastructure works, and the 2003 Italian Electronic Communications code.

3.2 Demand-side policies

The broadband-related objective pursued through the adoption of demand-side policies has been at least twofold. On one side, these policies have been used to stimulate the take-up of existing broadband infrastructures. On the other side, they have been used to increase the profitability of investors' business plans for the roll-out of Next Generation Networks, thus allowing areas where investment would not have been sustainable absent public intervention to become profitable. In the latter case, demand-side incentives act as catalysts for private investment in network rollout (Jeanjean, 2010). However, it should be noted that increasing broadband take-up or promoting network roll-out may not necessarily be the immediate goal of these policies, since some of them may be adopted with other objectives in mind, such as for instance improving the efficiency of the public sector, promoting ICT use by consumers and small businesses or enhancing e-inclusion of disadvantaged segments of the population. Each of the most relevant forms of demand-side intervention is considered in turn below.

Public demand of specific services.

In many countries governments have chosen to act as buyers and "lead users" of broadband technologies. In so doing, they increase the returns to investment in broadband, particularly in circumstances in which private demand is still latent, through the provision of new or improved e-government, e-health or e-education applications. Particularly widespread are initiatives of digitalization of the Public Administration, through which governments provide on-line information to citizens. Initiatives of this sort have been undertaken, among other countries, in Canada, Italy, Turkey and in Japan, where there has been an interesting attempt to radically improve on-line interactions between citizens and the PA.

Incentives to business demand.

This form of intervention, together with the incentives to private demand, aims at increasing businesses' awareness of the benefits from broadband access. Programs of enhancement of ICT penetration in SMEs tend to emphasize time and cost savings deriving from the adoption of some broadband applications such as digital payments and e-commerce. In Finland, the support to business demand aims to help firms adapting their business models to new broadband applications. In France, it has taken the form of the set-up of industrial districts characterized by the presence of ultra-broadband connections ("*Zones de Activité très Haut Débit*"). In Germany, the project "*Proteus*" encourages the adoption of specific standards for e-business activities and the German government has offered prizes and consultancy services for the development of innovative uses of broadband technologies in SMEs.

Incentives to private demand.

These policies are aimed at targeting "weak" segments of potential demand, characterized by a low propensity/ability to use novel technologies and made up primarily of housewives, schoolchildren and the elderly. They may take the form of IT alphabetization initiatives, advertizing campaigns, and/or educational vouchers. The leading nations in terms of adoption of this policy tool have surely been Japan (in particular with the "*IT Human Resource Development Plan*") and Korea ("10 Million People IT Education Project"), but many other nations have followed suit, as it is the case, for instance, for Ireland (*SchoolIT2000*), Mexico (*Sistema Nacional e-México*) and the Czech Republic (*State Information Policy in Education*). Some forms of incentive to private demand have also targeted citizens of rural communities, as it is the case for the project "*ConnectedNation*" in the US and the project "*Backing Indigenous Ability - BIA*" in Australia.

Demand subsidies.

Subsidies may be provided in the form of discounts on the purchase of equipment and/or broadband services, direct subsidies and/or tax breaks (Jeanjean, 2010). They may target individual consumers or particular categories of consumers, such as it is the case when they are used to finance the purchase of computers for broadband connectivity by families with students, as in Portugal and in Hungary, or other specific population groups (female population, low-income population, etc.) as in Greece. Moreover, they may be part of a more articulated strategy, as it is the case in Belgium, where policies adopted in 2006 (*Internet for Everyone*) and 2010 (*Start2surf@home*) have allowed citizens purchasing a bundle of broadband-related services (computer, software and broadband connectivity) from specific consortia to enjoy tax breaks.

Demand aggregation policies.

These are schemes aimed at coordinating the potential demand of consumers in order to ensure efficient resource allocation and the obtainment of economies of scale, so as to increase profitability of network rollout. In the UK, demand aggregation is achieved through the on-line registration of households' willingness to subscribe to broadband services both on British Telecom's website and on the government-run local development agencies. In Australia, with the 2006 "*Demand Aggregation Broker Broadband Program*", the government has promoted the creation of various sorts of intermediaries in the process of demand aggregation (national brokers, officers brokers and community-based brokers). Moreover, it has also released a manual explain the most successful strategies in terms of demand aggregation ("*Demand Aggregation Manual*"). In Korea and Turkey, demand aggregation has taken the form of the creation of public

internet access points (Internet Centers in Turkey and Internet Cafés in Korea), so as to aggregate demand in areas where it is particularly low and dispersed.

4. The Empirical Analysis: Data and Variables

We collect data from various sources and build a novel dataset in order to empirically investigate the impact of demand and supply side policies on broadband penetration. The final dataset covers 30 OECD countries[3] and collects a rich array of country-specific information about policy choices, telecommunications markets, socio-economic conditions and demographic characteristics. We employ a cross-country panel regression model, in which the rate of broadband diffusion at a country level is expressed as a function of individual countries' characteristics.

As dependent variable we use the one-year differences of an index of broadband penetration (*ΔBroadband*), which measures broadband subscribers per 100 inhabitants, where broadband lines include DSL lines, cable modem, optic fiber and LAN (source: ITU, 2010).

As the main explanatory variables we consider both demand- and supply-side policy indicators. In particular, the policy variables have been obtained from the *International Broadband Policies Database* (IBPD) (Rossi, 2010), which contains information on a large set of policies (both on the demand and supply side) implemented in 30 OECD countries through the 1995-2010 period. The *International Broadband Policies Database* registers, for each country, the adoption of individual policies, their temporal duration, and whether the individual policy is relevant at a national or regional level. This database provides an extremely useful and innovative information source, as previous databases were developed only for specific individual years or countries. Specifically, the *IBP* database covers six types of policies on the supply side, and 5 types of policies on the demand side.

On the supply side the following policies are included: (i) adoption of fiscal incentives programs and subsidies (*FiscalInc*), (ii) implementation of long-term loans programs for broadband suppliers and national financing programs (*LTLoans*), (iii) creation of Public-Private Partnerships with public ownership of the infrastructure network (*PublicNetPPP*), (iv) creation of Public-Private Partnerships with private ownership of the infrastructure network (*PrivateNetPPP*), (v)

[3] Countries included are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, South Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom (UK), United States of America (USA).

implementation of territorial mapping programs (*MapPrograms*), and (vi) initiatives of administrative simplification (*AdmSimpl*).

On the demand side the following policies are included: (i) initiatives of public demand of specific services (*PubDemServices*), (ii) provision of incentives to business demand (*IncBusinessDem*), (iii) provision of incentives to private demand (*IncPrivateDem*), (iv) provision of demand subsidies in favor of individual consumers or particular categories of consumers (*DemSubsidies*), and (v) adoption of demand aggregation policies (*DemAggregation*).

As one can notice, the IBPD's database covers most of the relevant policy measures for the promotion of broadband penetration that countries have adopted in the last fifteen years, and so it allows us to perform an exhaustive evaluation of the public intervention at a country level. In the IBPD's database, the adoption of each policy is codified as a discrete variable which takes the value of 1 if the individual policy measure is directed to a population share in between 0.5 and 25 percent of the total national population (i.e. it has local or regional relevance), 2 if it is directed to a population share greater than 25 percent of the total national population (i.e. it has a national wide relevance), 0 otherwise (i.e. it has no significant relevance).

The database offers yearly data, where the adoption of each policy is measured for each year in which the given intervention was in placed. The database also deals with the possibility of missing information regarding the duration of specific initiatives. In the database, two different coding strategies are followed in order to account for missing information. When only the information on the given year in which a policy initiative was launched is available (and the information on the duration of the initiative is not), according to a first strategy, the individual policy intervention is considered as being in place in all the years subsequent to the launch of the policy, while, according to a second strategy, the individual policy intervention is considered as being in place only in the given year in which the policy started. In our study we use the coding produced according to the first strategy, and then check the robustness of the estimation results to the second coding strategy.

Finally, we also consider two aggregate indicators for supply and demand side policies (again provided by the IBPD's (2010) database), which are built – for each country and year – as an un-weighted sum, respectively, of the six individual supply-side policy records and of the five individual demand-side policy records. Two aggregate indicators are so obtained: a supply side policy index (*SuppSidePolicies*) and a demand side policy index (*DemSidePolicies*), both of which are provided, again, according to the two different coding strategies previously described in order to account for missing information problems.

As control variables we consider a set of covariates measuring three dimensions possibly relevant for broadband diffusion, as suggested by the literature: telecommunications market characteristics, socio-economic conditions and demographic dynamics.

As telecommunications market characteristics we consider: the number of mobile cellular subscriptions per 100 inhabitants (*MobileDiffusion*; source: ITU (2010)), which we consider as a rough proxy for technological competition as suggested, among others, by Cava-Ferreruela and Alabau-Munoz (2006); the number of fixed telephone lines per 100 inhabitants (*FixedDiffusion*; source: ITU (2010)); the ratio of mobile cellular subscriptions to fixed telephone lines (*MobFixRatio*; source: ITU (2010)); the number of fixed Internet subscribers per 100 inhabitants (*InternetSubscr*; source: ITU (2010)); the number of Internet users per 100 inhabitants (*InternetUsers*; source: ITU (2010)); the level of liberalization in the telecommunications industry (*Liberalization*), measured as the reverse of the entry barriers to market index provided by OECD (2009); the level of privatization in the telecommunications industry (*Privatization*), measured as the reverse of the public ownership index provided by OECD (2009); and the level of competition in the telecommunications industry (*Competition*), measured through a composite index which expresses a weighted average of the market share of new entrants in the trunk telephony market, in the international telephony market, and in the mobile market (source: OECD, 2009).

As socio-economic characteristics we include the following variables: the degree of openness of the economy (*OpenEc*), measured as total trade – i.e. sum of import and export – as a percentage of GDP (source: Armingeon *et al.* (2010)); the gross domestic product growth rate (*GdpGrowth*; source: Armingeon *et al.* (2010)); the unemployment rate (*Unemployment*; source: Armingeon *et al.* (2010)); the civilian employment in services as a percentage of total civilian employment (*EmplServices*; source: Armingeon *et al.* (2010)); the tertiary school enrollment (*TertiaryEduc*), measured as the ratio of total enrollment in tertiary education institutions, regardless of age, to the population of the age group that officially corresponds to the level of education shown (source: World Bank, 2010), we use this variable as a proxy for informatics alphabetization; and the degree of decentralization of the State administrative structure (*Federalism*), measured through a discrete index that ranges from 0, if federalism is absent and centralization strong, to 2, if federalism is strong (source: Armingeon *et al.* (2010)).

As demographic variables, finally, we use information on: population aged between 15 and 64 years, expressed as a percentage of total population (*Pop15-64*; source: Armingeon *et al.* (2010)); population density per squared kilometer (*PopDensity*; source: ITU (2010)); urban population (*PopUrban*), measured as the population in cities with more than 1 million inhabitants expressed as a percentage of the total country's population (source: World Bank (2010)); female population

(*PopFemale*), i.e. the number of females as a percentage of total population (source: World Bank (2010)).

Table 1 reports a descriptive summary of the dataset.

[insert Table 1 about here]

5. The Empirical analysis: methodology and results

5.1 Basic regression methodology

The objective of the empirical analysis is to investigate the effect (if any) of both demand and supply side policies on the degree of broadband adoption in OECD countries, in order to suggest suitable public interventions for enhancing broadband diffusion. Specifically, here we aim at measuring how and to which extent public policies can explain, from a statistical point of view, the variability of an index of broadband penetration across 30 OECD countries over the 1999-2009 period, also taking into account the possible effect of telecommunications market conditions and of other socio-economic and demographic characteristics of individual countries.[4] As we have mentioned in the previous section, we use the one-year differences of an index of broadband penetration (*ΔBroadband*) as the dependent variable in our econometric model. The use of a one-year differentiated variable allows us to estimate precisely the effect of the presence of a given policy intervention in a certain year on the change of the (yearly) level of broadband adoption with respect to the preceding year.

We perform a basic regression analysis, in which the one-year changes in broadband diffusion are studied econometrically across all the 30 OECD countries included in our dataset over the entire 1995-2010 period. Thus, as a result we will obtain an estimate of the effect of an increase in the policy indicators on the dependent variable, averaged across the whole considered country sample and time period.

Formally, we consider the following cross-country panel model:

[4] While IBPD's (2010) data cover the 1995-2010 period, broadband diffusion data for OECD countries are available for the years from 1999 to 2009, thus in our econometric analysis we finally study the 1999- 2009 period. Notice that we encounter some missing data (for given years and countries) for some variables and therefore end up with an unbalanced panel (depending on the variables used the sample size changes across the various model specifications that we consider). As panel analysis methods allow to tackle unbalanced panels, our estimation results do not suffer from biasness problems, that we check for through traditional diagnostic procedures.

$$\Delta Broadband_{it} = \beta_0 + \sum_k \beta_k \mathbf{K}_{it} + \sum_l \beta_l \mathbf{L}_{it} + \sum_m \beta_m \mathbf{M}_{it} + \sum_n \beta_n \mathbf{N}_{it} + \sum_r \beta_r \mathbf{R}_{it} + c_i + \varepsilon_{it} \quad (1)$$

with t = 1995, 1996, …, 2010, and where i identifies the country, **K** is a vector of supply-side policy indicators, **L** is a vector of demand side policy indicators, **M** is a vector of telecommunications industry's market conditions, **N** is a vector of socio-economic variables, **R** is a vector of demographic characteristics, $\beta_{0...r}$ defines the parametric structure of the equation, c_i captures the country-specific effects (that soak up the variability in the data due to time invariant unobservable country factors), and where ε_{it} are idiosyncratic disturbances that change across countries (i) and years (t).

Note that, as a baseline estimation method, we perform a random-effects estimation, in which individual country heterogeneity is explicitly incorporated into the model, by treating the unobserved effects as random draws from the population. This approach is commonly preferred to a fixed-effects estimation from the so-called 'omitted variables' or 'neglected heterogeneity' perspective (Wooldridge, 2002).[5]

5.2 Baseline models' estimation results

Broadband penetration (at a country level) is potentially affected by a very large set of variables. In our study we try to take into account all the possibly relevant aspects. As a result, we include in the analysis a set of individual supply- and demand-side polices along with three vectors each containing a sub-set of variables, in order to control for telecommunications markets, socio-economic and demographic factors.

This rich array of variables, however, prevents us from estimating a full model containing all the predictors as, by doing so, our estimation would suffer from a large loss of degrees of freedom. Thus, we undertake an empirical strategy according to which the relevant variables are selected through a *three-step estimation strategy*.

[5] We have checked, through the Hausman test, the statistical validity of the assumption of orthogonality between the random effects and the regressors, which is made in the random effects model. In some of the model specifications that we consider, the results of the Hausman test allows us to statistically accept the null hypothesis of random effects estimation's parameters consistent and efficient versus a fixed effects estimation's parameters. Those specifications for which the Hausman's null hypothesis is rejected are estimated through a fixed effects estimation based on a "within transformation", according to which the (generic) constant term is estimated as an average of the unobserved components.

In a first step, we investigate econometrically the relationship between each individual policy intervention and the one-year changes of broadband diffusion. In this way we show how individual policy measures relate to broadband penetration. In a second step, we employ the aggregate supply- and demand-side policy indicators (so as to reduce the overall number of policy regressors), and check the statistical effect of such aggregate indexes on broadband diffusion controlling for individual country characteristics. In the third step, finally, we select those control variables that are shown to potentially affect broadband adoption in the second step, and construct extended model versions in which redundant regressors are not included.

Results are presented in tables from 2 to 5. In each table, while the first column lists the variables, the remaining columns report estimated parameters and standard errors. Where a fixed effects estimation is performed (notice that the choice between random and fixed effects model is made on the base of the Hausman test's results, reported at the bottom of each table), standard errors are heteroskedasticity robust.

i. Individual public policies' effects

Table 2 shows two important results. On the one hand, only three supply-side interventions have a positive and statistically significant effect on *ΔBroadband*: they are the implementation of long-term loans programs for broadband suppliers and national financing programs (*LTLoans*), and the creation of Public-Private Partnerships with both public or private ownership of the infrastructure network (respectively, *PublicNetPPP* and *PrivateNetPPP*). The other supply side policy measures seem to have lower effects on *ΔBroadband*, and such effects (if any) do not turn out to be statistically significant: this is the case of fiscal incentives programs (*FiscalInc*), implementation of territorial mapping programs (*MapPrograms*), and administrative simplification (*AdmSimpl*). On the other hand, all the demand-side policies that we have considered are shown to affect the one-year broadband diffusion changes: initiatives of public demand of specific services (*PubDemServices*), the provision of incentives to business demand (*IncBusinessDem*) or to private demand (*IncPrivateDem*), the provision of demand subsidies in favor of individual consumers or particular categories of consumers (*DemSubsidies*), and the adoption of demand aggregation policies (*DemAggregation*) all have a positive and statistically significant effect on *ΔBroadband*. Moreover, unreported estimations in which we used the alternative coding provided by the IBPD's (2010) database show substantially similar results, so suggesting that different treatments of missing information do not significantly affect the parameter estimates.

[insert Table 2 about here]

ii. Aggregate policy indexes' effects and selection of control variables

Table 3 reports the estimation results obtained from a set of model specifications in which individual control covariates (measuring telecommunications markets, socio-economic and demographic factors) are added to the two aggregate indicators for supply and demand side policies.

As a main result, we obtain that both the aggregate supply- and demand-side policy indexes (respectively, *SuppSidePolicies* and *DemSidePolicies*) have a positive and statistically significant effect on broadband diffusion changes at a country level. This is shown by all the model specifications reported in Table 3. Only in the model specifications reported in columns (I) and (IV), the parameter associated to the index for supply-side policies does not turn out to be statistically significant.

Secondly, estimation results reported in Table 3 unveil which explanatory controls might have a statistically significant effect on *ΔBroadband*. Among those variables that describe telecommunications markets' characteristics, we find that the number of mobile cellular subscriptions per 100 inhabitants (*MobileDiffusion*), which we consider as a rough proxy for technological competition, has a positive impact on broadband penetration, along with the number of fixed Internet subscribers and users per 100 inhabitants (*InternetSubscr* and *InternetUsers*). The degree of competition in the telecommunications industry also emerges as an important dimension: on the one side, indeed, we find that the level of legal liberalization in the telecommunications industry (*Liberalization*) has a positive effect on *ΔBroadband*; on the other, the actual competition in the market (*Competition*) appears statistically relevant as well. Privatization levels (*Privatization*), instead, do not have statistically significant influences. Among those variables that capture socio-economic factors, we detect a positive and statistically significant effect for the rate of enrollment in tertiary education institutions (*TertiaryEduc*), for the level of unemployment (*Unemployment*) and for the share of civilian employees in services (*EmplServices*). Other variables, such as the degree of economic openness (*OpenEc*), GDP growth (*GdpGrowth*) and administrative decentralization (*Federalism*) do not seem to play a statistically significant role. As for demographic dynamics, finally, higher quotas of population aged between 15 and 64 years (*Pop15-64*) result to be statistically associated to higher levels in the broadband diffusion changes, while higher quotas of female population (*PopFemale*) to lower ones.

[insert Table 3 about here]

iii. Aggregate policy indexes' effects controlling for vectors of country characteristics

Table 4 presents estimation results obtained by using extended model versions in which redundant regressors are not included. In particular, we consider four model specifications, where the explanatory variables (both policy indicators and control regressors) are added through vectors of multiple variables. Models presented in columns from (I) to (III) of Table 4 include supply- and demand-side policy indicators along with a vector capturing, respectively, relevant telecommunications markets, socio-economic and demographic factors. Model specification (IV) includes the supply- and demand-side policy indexes and those variables that are shown to be associated to a statistically significant parameter in the model specifications from (I) to (III). Moreover, notice that in all the models from (I) to (IV) of Table 4 we have also considered a one-year lagged supply side policy index ($SuppSidePolicies_{it-1}$), in order to control for delayed effects of supply-side public interventions.[6]

[insert Table 4 about here]

Estimation results presented in Table 4 show that demand-side policies (*DemSidePolicies*) always have a positive and statistically significant impact on $\Delta Broadband$, both when the control vectors are considered one by one (see specifications from (I) to (III)) and when they are included simultaneously (see specification (IV), where those regressors that were previously shown to be non-significant are excluded). On the contrary, supply side policies turn out to have a positive and statistically significant impact on broadband adoption only when one-year lagged policies are considered ($SuppSidePolicies_{it-1}$) and when controlling for socio-economic and demographic factors, while when also telecommunications markets characteristics are included both $SuppSidePolicies_{it-1}$ and $SuppSidePolicies_{it}$ are not associated to statistically significant parameters.

As for the control variables, Table 4 also confirms that mobile cellular subscriptions per 100 inhabitants (*MobileDiffusion*), the actual degree of competition in the market (*Competition*), and the level of civilian employees in services (*EmplServices*) all act as a positive and statistically significant influence on the rate of broadband adoption. These latter results reveal the crucial role of both

[6] Although both the number of fixed Internet subscribers per 100 inhabitants (*InternetSubscr*) and the number of Internet users per 100 inhabitants (*InternetUsers*) were previously shown to be associated to a statistically significant parameter, here we consider only *InternetUsers*, given that *InternetUsers* and *InternetSubscr* show a high correlation coefficient ($\rho = 0.857$, p-value = 0.000; this implying collinearity problems).

technological and inter-firm competition for the enhancement of broadband penetration, along with a demand-specific factor (i.e. the relevance of the service sector in the economy). Instead, the remaining variables (*InternetUsers*, *Liberalization*, *Unemployment*, *TertiaryEduc*, *Pop15-64*, and *PopFemale*) do not appear to have statistically significant effects once they are included simultaneously into the model.

5.3 Quantile regression analysis: policy timing and sequencing

Another important issue to be considered when analyzing the impact of broadband policies, is whether a different policy design is needed according to the level of existing broadband diffusion. For instance, supply and/or demand-side policies may have a rather different impact under a low rate of broadband penetration relative to the one they can extert under high levels of broadband diffusion.

In order to tackle this problem, in this section we perform a quantile regression analysis (Koenker and Basset, 1978). Quantile regression is a statistical technique intended to conduct inference about conditional quantile functions. Just as traditional linear regression methods enable one to estimate models for conditional mean functions, quantile regression techniques offer a mechanism for estimating models for the conditional median and other conditional quantile functions. Thus, quantile regression enables us to provide a more complete statistical analysis of the stochastic relationships among variables.

Here, in particular, we estimate the effect of supply and demand-side policies (and of a set of control regressors) on the level of broadband diffusion corresponding to the median value of broadband penetration for our sample, and to the levels corresponding to the 3rd and the 7th quantile. We choose the 3rd and the 7th quantile since they identify two quantiles equally distant from the median and since they do not refer to extreme values of the distribution. The dependent variable we use here is the level of broadband penetration (*Broadband*), rather than its one-year changes. As a byproduct, hence, the 3rd, the 5th and the 7th quantile that we consider in our regression will correspond to three different stages of the broadband market development, defined in terms of rate of broadband adoption (say low, middle and advanced broadband adoption).

The linear conditional quantile function is estimated by solving:

$$\beta(\tau) = \text{argmin}_{\beta \in R} \sum_i \rho_\tau (Broadband_{it} - x'_{it}\beta) \quad (2)$$

for any quantile τ (between 0 and 1), where the quantity $\beta(\tau)$ is called the τ-th regression quantile, $\rho(\cdot)$ is the function that yields the τ-th sample quantile as its solution, and x' identifies a generic covariate.

Estimated parameters from quantile regressions are presented in Table 5. Interesting results are obtained.

First, quantile regression findings show that, while supply-side policies have a positive and statistically significant effect on broadband diffusion only if one-year lagged and only for the 3rd and 5th quantile, demand-side policies do exert a positive influence for all the quantiles considered. Moreover, the estimated coefficient for demand-side policies increases throughout the three considered quantiles of the broadband diffusion distribution (always being statistically significant). This result is particularly informative as it provide suggestions as to the appropriate policy sequencing to be adopted. When the broadband market is at its first stages of development (i.e. the levels of broadband penetration are low), both supply- and demand-side policies have a positive effect, with supply-side policies showing one-year delayed effects.

When broadband diffusion increases up to our sample average, again, both one-year lagged supply-side policies and demand-side interventions continue to play a positive and statistically significant role, with however the estimated effect of supply-side policies being reduced (from 0.862 to 0.676) and that of demand-side policies being increased (from 0.659 to 0.905). Finally, when the telecommunications market reaches an advanced stage of development (i.e. our 7th sample quantile), only demand-side policies appear to have a positive and statistically significant effect on the rate of broadband adoption, and such effect is shown to be higher than that exerted in the previous stages of market development.

Second, quantile regressions confirm the positive influence played by technological competition (which we measure through the rate of mobile subscribers, *MobileDiffusion*) and confirm the influential role of market competition (*Competition*). In particular, although always positive, the magnitude of the effect of market competition seems to follow a non linear path throughout the stages of the broadband market development. Indeed, the estimated coefficient of *Competition* for the 3rd quintile is around 1.4, then it decreases to 1.2 in correspondence of the 5th quintile, and again it grows to 1.7 at the 7th quintile.

Third, finally, the level of civilian employees in services (*EmplServices*) is shown to act as a positive and statistically significant influence on the rate of broadband adoption for all the three quintiles that we have considered. Furthermore, the estimated parameter increases significantly from the 3rd to the 7th quintile (where it is equal, respectively, to 17.1 and 46.6). This result further highlights the relevance of demand-side factors for broadband diffusion.

6. Conclusions

Broadband penetration is widely perceived as having a significant potential for economic growth. However, the empirical research on the most appropriate public policy design needed to enhance broadband penetration, is still in its infancy. The objective of this paper has been to attempt to fill this gap, by providing an empirical analysis, based on a unique and novel dataset, of the relative effectiveness of a wide range of supply-side and demand-side policy interventions aimed at stimulating broadband penetration.

So-far, the lack of empirical analyses specifically focused on the policy side of the broadband debate may be motivated by a number of reasons that include the difficulty of gathering adequate information for a number of countries sufficient to make the analysis meaningful in a policy context that is permanently in flux. One of the strengths of this paper is that it relies on a dataset (IBPD) assembled on the basis of such time-consuming process of information-gathering. Indeed, the data on the policies adopted in the 30 OECD countries considered in the study have been carefully retrieved on the basis of an extensive analysis of the existing academic literature, of consulting firms' reports, official documents and governments' and newspapers' websites.

The present paper makes a first step in the direction of providing some information that may constitute the basis for effective broadband policy interventions. The results of the analysis are good news for policy-makers. Indeed, differently from the scant existing empirical evidence mentioned, we show that public policies do exert a positive influence on broadband penetration. This holds for both demand-side and supply-side policies. In other words, the efforts undertaken by most OECD governments appear to be well-grounded. At a time in which the financial crisis made governments' budget constraints ever more binding, the renewed impetus for the adoption of infrastructure-centred Keynesian policies, thus finds in broadband policies a successful agenda to be implemented.

Two conclusions from our findings may be most useful to policy-makers in the short term. The first is that demand-side policies show, on the aggregate, to have greater impact on broadband penetration than supply-side interventions, especially when endogeneity issues are explicitly addressed. This is to some extent surprising, in light of the fact that most of the attention has been historically placed on supply-side interventions, with demand-side interventions being considered a useful, though not essential, component of a broadband policy plans.

The second, and most important, is that the adoption of piecemeal policies does not take too far. Governments electing broadband penetration as a worthy policy goal should take

seriously the existence of complementarities among the various policy tools available, and particularly among demand-side and supply-side policies. Policy interventions should be devised in the context of an overall articulated strategy that combines elements of demand-side and supply-side stimulus. In particular, our quantile regression shows that appropriate policy sequencing shall be adopted, according to the initial conditions faced in each country. When the broadband market is at its first stages of development, and the levels of broadband penetration are low), both supply and demand-side policies have a positive effect, with supply-side policies showing one-year delayed effects. However, when broadband diffusion increases demand-side policies appear to have a positive and statistically significant effect on the rate of broadband adoption, and such effect is shown to be higher than that exerted in the previous stages of market development. Other 'initial conditions' which affect policy's performance are given by the level of technological competition on the one hand, and of market competition on the other. In particular, although always positive, the magnitude of the effect of market competition follows a non linear path throughout the stages of the broadband penetration development, being high for initial and mature stage, and lower for intermediate levels of broadband penetration. Finally, the relevance of demand-side factors for broadband diffusion is confirmed by the role played by the level of civilian employees in services, which positively influence the rate of broadband penetration at any stage of broadband diffusion.

We believe that our results provide new insights into the policy debate and in particular by outlining the rationale of a selective policy design for broadband penetration and, in perspective, for the rollout of next-generation networks, based on the complementarity of supply-side and demand-side, according to country-specific conditions.

One limit of our analysis is that the dataset we use, does not cover so-far wireless broadband policies adopted in the sample of countries we study. We are aware that this might be a remarkable weakness for our policy implications, as the complementarity between wireline and wireless broadband diffusion is clearly a fundamental issue, especially with reference to future policies aimed at reducing the digital divide. Future research shall focus on such a neglected issue, in order to improve our understanding of the optimal degree of complementarity between wireless and wireline broadband adoption, for the implementation of an appropriate policy design.

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Table 1. Control variables' description.

	VARIABLE'S NAME	VARIABLE'S DEFINITION	SOURCE	MEAN	S.D.
Supply side policies	*FiscalInc*	Fiscal incentives programs	IBPD (2010)	0.083	0.394
	LTLoans	Long-term loans programs	IBPD (2010)	0.804	0.968
	PublicNetPPP	PPP with network's public ownership	IBPD (2010)	0.450	0.757
	PrivateNetPPP	PPP with network's private ownership	IBPD (2010)	0.177	0.559
	MapPrograms	Territorial mapping programs	IBPD (2010)	0.016	0.170
	AdmSimpl	Administrative simplification	IBPD (2010)	0.043	0.289
	SuppSidePolicies	Supply side policies aggregate index	IBPD (2010)	1.575	1.793
Demand side policies	*PubDemServices*	Public demand of specific services	IBPD (2010)	1.393	0.907
	IncBusinessDem	Incentives to business demand	IBPD (2010)	0.227	0.630
	IncPrivateDem	Incentives to private demand	IBPD (2010)	0.887	0.960
	DemSubsidies	Demand subsidies for consumers	IBPD (2010)	0.204	0.599
	DemAggregation	Demand aggregation policies	IBPD (2010)	0.541	0.324
	DemSidePolicies	Demand side policies aggregate index	IBPD (2010)	2.759	2.102
Market characteristics	*MobileDiffusion*	Mobile cellular subscriptions (per 100 inh.)	ITU (2010)	83.712	30.115
	FixedDiffusion	Fixed telephone lines (per 100 inh.)	ITU (2010)	47.805	13.335
	MobFixRatio	Mobile to fixed lines ratio	ITU (2010)	1.883	0.958
	InternetSubscr	Fixed Internet subscribers (per 100 inh.)	ITU (2010)	19.877	10.758
	InternetUsers	Internet users (per 100 inh.)	ITU (2010)	49.624	24.038
	Liberalization	Telecommunications industry's liberalization	OECD (2009)	4.649	2.122
	Privatization	Telecommunications industry's privatization	OECD (2009)	3.610	2.227
	Competition	Level of competition in the industry	OECD (2009)	2.358	1.368
Socio-economic characteristics	*OpenEc*	Degree of economic openness (% of GDP)	Armingeon *et al.* (2010)	85.670	51.831
	GdpGrowth	GDP growth rate (%)	Armingeon *et al.* (2010)	2.949	1.970
	Unemployment	Unemployment rate (%)	Armingeon *et al.* (2010)	6.674	3.394
	EmplServices	Employment in services (% of total empl.)	Armingeon *et al.* (2010)	0.687	0.059
	TertiaryEduc	Tertiary schools enrollment (% relevant pop.)	World Bank (2010)	56.936	18.156
	Federalism	Index of administrative decentralization	Armingeon *et al.* (2010)	0.571	0.850
Demographic characteristic	*Pop15-64*	Population aged 15-64 (% of total pop.)	Armingeon *et al.* (2010)	0.668	0.012
	PopDensity	Individuals per Km2	ITU (2010)	131.95	121.51
	PopUrban	Urban population (% of total pop.)	World Bank (2010)	26.146	13.803
	PopFemale	Female population (% of total pop.)	World Bank (2010)	50.351	0.563

Table 2. Individual public policies' effects (cross-country panel model estimates).

VARIABLE	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)
	||---------- SUPPLY SIDE POLICIES ----------||						||---------- DEMAND SIDE POLICIES ----------||				
DEP. VAR.: $\Delta Broadband_{it}$	Coeff. (Std.Err.)	Coeff. (Std.Err.)	Coeff. (Std.Err.)	Coeff. (Std.Err.)	Coeff. (Std.Err.)	Coeff. (Std.Err.)	Coeff. (Std.Err.)	Coeff. (Std.Err.)	Coeff. (Std.Err.)	Coeff. (Std.Err.)	Coeff. (Std.Err.)
$FiscalInc_{it}$	-0.164 (0.350)										
$LTLoans_{it}$		0.447 (0.134) [a]									
$PublicNetPPP_{it}$			0.646 (0.162) [a]								
$PrivateNetPPP_{it}$				0.519 (0.210) [b]							
$MapPrograms_{it}$					-0.028 (0.576)						
$AdmSimpl_{it}$						0.150 (0.361)					
$PubDemServices_{it}$							0.350 (0.191) [c]				
$IncBusinessDem_{it}$								0.633 (0.136) [a]			
$IncPrivateDem_{it}$									0.457 (0.138) [a]		
$DemSubsidies_{it}$										1.059 (0.175) [a]	
$DemAggregation_{it}$											0.993 (0.349) [a]
Constant	2.596 (0.156) [a]	2.108 (0.201) [a]	2.221 (0.167) [a]	2.449 (0.155) [a]	2.582 (0.152) [a]	2.572 (0.151) [a]	1.994 (0.355) [a]	2.389 (0.127) [a]	2.059 (0.219) [a]	2.313 (0.126) [a]	2.502 (0.152) [a]
Number of obs.	300	300	300	300	300	300	300	300	300	300	300
Country effects	Random	Random	Random	Random	Random	Random	Random	Fixed	Random	Fixed	Random
Hausman test: [prob. > *chi2*]	0.12 [0.72]	0.15 [0.70]	1.41 [0.23]	0.10 [0.74]	1.17 [0.28]	2.51 [0.11]	1.16 [0.28]	H_0 rejected	1.34 [0.24]	H_0 rejected	1.33 [0.24]
Prob. > *F*	--	--	--	--	--	--	--	0.000	--	0.000	--
R-squared (between)	0.012	0.138	0.174	0.104	0.036	0.059	0.016	0.196	0.034	0.013	0.058

Statistical significance: [a] = 0.01; [b] = 0.5; [c] = 0.10. Note: where fixed effects estimation is performed, standard errors are heteroskedasticity robust.

Table 3. Aggregate policy indexes' effects and selection of control variables (cross-country panel model estimates).

VARIABLE	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)	(XII)	(XII)	(XIV)	(XV)	(XVI)	(XVII)	(XVIII)
DEP. VAR.: $\Delta Broadband_{it}$	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)
SuppSidePolicies $_{it}$	0.151 (0.113)	0.318 (0.107) [a]	0.238 (0.108) [b]	0.092 (0.070)	0.157 (0.103)	0.492 (0.109) [a]	0.483 (0.108) [a]	0.379 (0.106) [a]	0.469 (0.123) [a]	0.241 (0.094) [b]	0.344 (0.121) [a]	0.062 (0.124)	0.294 (0.116) [b]	0.258 (0.094) [a]	0.337 (0.123) [a]	0.317 (0.107) [a]	0.803 (0.156) [a]	0.278 (0.116) [b]
DemSidePolicies $_{it}$	0.361 (0.063) [a]	0.389 (0.063) [a]	0.384 (0.064) [a]	0.209 (0.063) [a]	0.339 (0.063) [a]	0.360 (0.083) [a]	0.376 (0.085) [a]	0.283 (0.086) [a]	0.354 (0.109) [a]	0.199 (0.093) [b]	0.393 (0.091) [a]	0.358 (0.085) [a]	0.349 (0.096) [a]	0.218 (0.092) [b]	0.379 (0.085) [a]	0.412 (0.066) [a]	0.284 (0.133) [b]	0.453 (0.080) [a]
MobileDiffusion $_{it}$	0.017 (0.006) [a]																	
FixedDiffusion $_{it}$		0.024 (0.026)																
MobFixRatio $_{it}$			0.241 (0.160)															
InternetSubscr $_{it}$				0.085 (0.012) [a]														
InternetUsers $_{it}$					0.029 (0.008) [a]													
Liberalization $_{it}$						0.456 (0.113) [a]												
Privatization $_{it}$							0.297 (0.190)											
Competition $_{it}$								1.777 (0.341) [a]										
OpenEc $_{it}$									0.012 (0.022)									
GdpGrowth $_{it}$										-0.015 (0.094)								
Unemployment $_{it}$											0.290 (0.168) [c]							
EmplServices $_{it}$												53.871 (12.391) [a]						
TertiaryEduc $_{it}$													0.100 (0.027) [a]					
Federalism $_{it}$														0.185 (0.223)				
Pop15-64 $_{it}$															56.880 (34.140) [c]			
PopDensity $_{it}$																-0.036 (0.054)		
PopUrban $_{it}$																	-0.014 (0.019)	
PopFemale $_{it}$																		-8.533 (2.186) [a]
Constant	-0.549 (0.392)	-0.597 (1.358)	0.281 (0.279)	-0.088 (0.335)	-0.454 (0.324)	-2.045 (0.633) [a]	-0.789 (0.730)	-4.309 (0.911) [a]	-0.269 (2.014)	1.858 (0.489) [a]	-0.790 (1.137)	-36.035 (8.405) [a]	-5.228 (1.412) [a]	1.595 (0.433) [a]	-37.060 (22.841)	5.332 (7.008)	0.505 (0.675)	429.929 (110.23) [a]

(continues)

(Table 3 continued)

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)	(XII)	(XII)	(XIV)	(XV)	(XVI)	(XVII)	(XVIII)
Number of obs.	300	300	300	263	300	232	232	232	168	185	189	189	171	189	189	300	52	210
County effects	Fixed	Fixed	Fixed	Random	Fixed	Fixed	Fixed	Fixed	Fixed	Random	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Random	Fixed
Hausman test: [p. > *chi2*]	H_0 rej.	H_0 rej.	H_0 rej.	4.21 [0.23]	H_0 rej.	H_0 rej.	H_0 rej.	H_0 rej.	H_0 rej.	5.99 [0.11]	H_0 rej.	H_0 rej.	H_0 rej.	H_0 rej.	H_0 rej.	H_0 rej.	1.80 [0.61]	H_0 rej.
Prob. > *F*	0.000	0.000	0.000	--	0.000	0.000	0.000	0.000	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	--	0.000
R-sq. (between)	0.166	0.313	0.040	0.799	0.569	0.278	0.035	0.193	0.080	0.051	0.008	0.632	0.304	0.065	0.011	0.022	0.534	0.155

Statistical significance: [a] = 0.01; [b] = 0.5; [c] = 0.10. Note: where fixed effects estimation is performed, standard errors are heteroskedasticity robust.

Table 4. Aggregate policy indexes' effects and vectors of control variables (cross-country panel model estimates).

	VARIABLE	(I)	(II)	(III)	(IV)
	DEP. VAR.: $\Delta Broadband_{it}$	Coeff. (Std.Err.)	Coeff. (Std.Err.)	Coeff. (Std.Err.)	Coeff. (Std.Err.)
Policy indexes	$SuppSidePolicies_{it-1}$	0.131 (0.106)	0.303 (0.127) [b]	0.223 (0.127) [c]	0.132 (0.111)
	$SuppSidePolicies_{it}$	0.145 (0.091)	-0.031 (0.123)	0.109 (0.113)	-0.066 (0.103)
	$DemSidePolicies_{it}$	0.179 (0.084) [b]	0.378 (0.116) [a]	0.299 (0.128) [b]	0.247 (0.099) [b]
Tlc market factors	$MobileDiffusion_{it}$	0.029 (0.013) [b]			0.058 (0.009) [a]
	$InternetUsers_{it}$	0.021 (0.018)			
	$Liberalization_{it}$	-0.172 (0.149)			
	$Competition_{it}$	0.675 (0.394) [c]			0.661 (0.290) [b]
Socio-economic factors	$Unemployment_{it}$		0.054 (0.102)		0.089 (0.086)
	$EmplServices_{it}$		18.269 (4.907) [a]		14.252 (4.668) [a]
	$TertiaryEduc_{it}$		0.043 (0.015) [a]		0.009 (0.016)
Demographic factors	$Pop15\text{-}64_{it}$			30.832 (57.039)	
	$PopFemale_{it}$			-11.903 (3.352) [a]	-0.337 (0.652)
	Constant	-2.868 (0.804) [a]	-14.675 (3.607) [a]	578.194 (188.808) [a]	1.078 (34.550)
	Number of obs.	232	116	147	116
	Country effects	Fixed	Random	Fixed	Random
	Hausman test: [prob. > *chi2*]	H_0 rejected	1.23 [0.97]	H_0 rejected	2.89 [0.96]
	Prob. > *F*	0.000	--	0.000	--
	R-squared (between)	0.530	0.371	0.060	0.561

Statistical significance: [a] = 0.01; [b] = 0.5; [c] = 0.10.
Note: where fixed effects estimation is performed, standard errors are heteroskedasticity robust.

Table 5. Quantile regression results.

	VARIABLE	3RD QUANTILE REGRESSION	MEDIAN REGRESSION	7TH QUANTILE REGRESSION
	DEP. VAR.: *Broadband*$_{it}$	Coeff. (Std.Err.)	Coeff. (Std.Err.)	Coeff. (Std.Err.)
Policy indexes	*SuppSidePolicies*$_{it-1}$	0.862 (0.237) [a]	0.676 (0.386) [c]	0.899 (0.690)
	SuppSidePolicies$_{it}$	-0.227 (0.198)	-0.236 (0.344)	-0.890 (0.645)
	DemSidePolicies$_{it}$	0.659 (0.128) [a]	0.905 (0.270) [a]	1.145 (0.471) [b]
Tlc market factors	*MobileDiffusion*$_{it}$	0.073 (0.012) [a]	0.105 (0.023) [a]	0.104 (0.041) [b]
	Competition$_{it}$	1.445 (0.293) [a]	1.231 (0.618) [b]	1.735 (1.027) [c]
Socio-economic factors	*Unemployment*$_{it}$	0.044 (0.096)	0.307 (0.188)	0.084 (0.342)
	EmplServices$_{it}$	17.118 (5.041) [a]	33.193 (9.732) [a]	46.607 (16.904) [a]
	TertiaryEduc$_{it}$	-0.021 (0.020)	0.007 (0.036)	0.047 (0.064)
Demographic factors	*PopFemale*$_{it}$	0.427 (0.744)	1.199 (1.346)	1.535 (2.416)
	Constant	-41.574 (39.303)	-95.248 (71.196)	-120.881 (126.868)
	Number of obs.	136	136	136
	Pseudo R-squared	0.286	0.362	0.389

Statistical significance: [a] = 0.01; [b] = 0.5; [c] = 0.10.